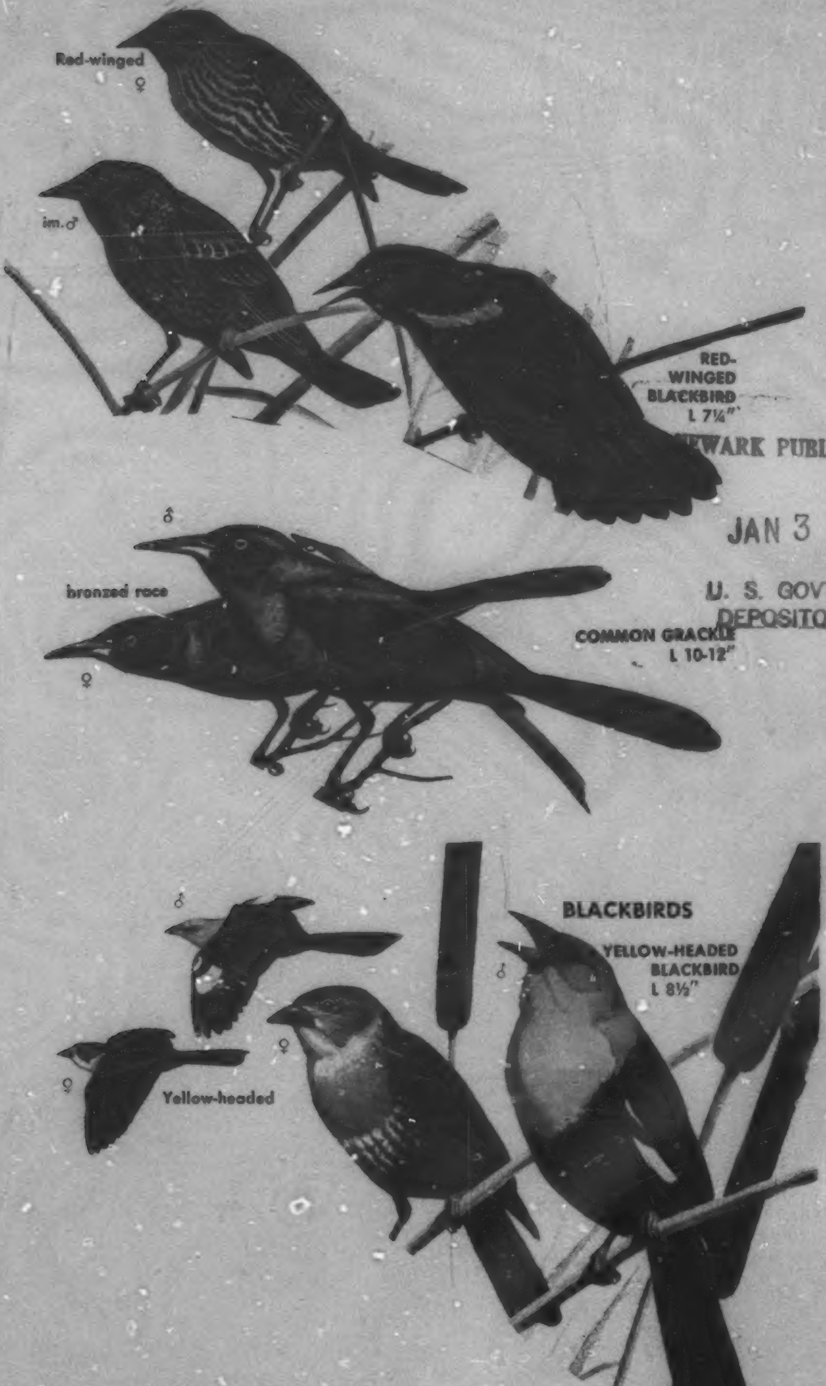
G-91

# A GROWERS' GUIDE TO REDUCING BIRD DAMAGE TO U.S. AGRICULTURAL CROPS


Red-winged
♀
im.♂
RED-
WINGED
BLACKBIRD
L 7¼"
♂
bronzed race
♀
COMMON GRACKLE
L 10-12"
BLACKBIRDS
YELLOW-HEADED
BLACKBIRD
L 8½"
♂
♂
♀
♀
Yellow-headed

NEWARK PUBLIC LIBRARY
JAN 3 1986
U. S. GOVT. PUBS.
DEPOSITORY 37[illegible]

I 49. 6/2:

Denver Wildlife Research Center

U. S. Fish and Wildlife Service

Bird Damage Research Report No. 340

July 1985

# A Growers Guide to Reducing Bird Damage to U. S. Agricutural Crops

Jerome F. Besser

Abstract:

Bird damage to U. S. agricultural crops is a problem that costs growers more than $100 million annually. However, serious losses are suffered by a small percentage of growers. Methods for protection of most crops against most species of birds are available but are often less effective, particularly cost-effective, than desired. Some methods, particularly chemical methods, have been developed in the last two decades that have potential for alleviating much of the most serious damage to many major U. S. crops, particularly sprouting and ripening grains, and ripening oil seeds and fruit. However, most of these methods have not been widely employed and many require refinement by the grower for their special damage situations. For minor U. S. crops and those major crops less regularly damaged by birds, cost-effective control procedures often await identification of the loss to provide an incentive to industry to further develop potential damage alleviation measures.

# A GROWERS' GUIDE TO REDUCING BIRD DAMAGE TO U.S. AGRICULTURAL CROPS

## Contents

Page

INTRODUCTION 2

IDENTIFICATION OF LOSSES CAUSED BY BIRDS 3

IDENTIFICATION OF SPECIES CAUSING LOSSES 3

IDENTIFICATION OF THE AMOUNT OF LOSSES 3

LEGAL STATUS OF CONTROL OF PROBLEM SPECIES 7

METHODS AVAILABLE TO REDUCE DAMAGE 7

SOME GENERAL CULTURAL PRACTICES FOR REDUCING BIRD DAMAGE 8

REDUCING BIRD DAMAGE TO SPECIFIC CROPS 8

GRAINS - ROW CROPS 8

CORN 8

Sprouting Corn 9
Protection of Sprouting Corn 11
Ripening Field Corn 12
Protection of Ripening Field Corn 13
Sweet Corn 18
Protection of Sweet Corn 19

GRAIN SORGHUM (MILO MAIZE) 20

Protection of Grain Sorghum 21

GRAINS - NON-ROW CROPS 22

RICE 22

Sprouting Rice 23
Protection of Sprouting Rice 24
Ripening Rice 25
Protection of Ripening Rice 26
Wild Rice 27

WHEAT 27

Protection of Sprouting Wheat 29
Protection of Ripening Wheat 29
Protection of Swathed Wheat 29

READEX

CONTENTS - Continued

Page

BARLEY 31

OATS 31

RYE 32

OILSEEDS 32

SUNFLOWER 32

Protection of Sunflower 34

PEANUTS 37

Protection of Peanuts 37

SOYBEANS 38

FLAXSEED 38

FRUIT CROPS 38

GRAPES 39

Protection of Grapes 40

CHERRIES 40

Protection of Cherries 41

BLUEBERRIES 42

Protection of Blueberries 43

APPLES 43

OTHER FRUITS 44

NUT CROPS 45

PECANS 45

OTHER NUTS 46

VEGETABLE CROPS 46

Protection of Vegetable Crops 47

CONTENTS - Continued

Page

ROOT CROPS 48

HAY CROPS 48

FEED GRAINS 48

Protection of Feed Grains 50

ADDITIONAL SOURCES OF INFORMATION 52

SUMMARY 53

ACKNOWLEDGMENT 53

REFERENCES CITED 54

APPENDIXES 68

GLOSSARY 89

## Appendixes

A. Estimated annual losses for specific U.S. agricultural crops.

B. Daily damage capabilities of selected species of birds and specific stages of some U.S. agricultural crops.

C. A table of 200 random 2-digit numbers for locating random sampling points in crop fields.

D. Federal permit requirements for scaring or killing birds damaging U.S. agricultural crops.

E. Common and scientific names of birds damaging crops.

F. Methods available to protect U.S. agricultural crops from bird damage.

G. Sources of supply of non-chemical materials useful for protecting U.S. agricultural crops from bird damage.

H. Chemical products registered for protecting U.S. agricultural crops from bird damage (manufacturer addresses appended).

I. Preferred method of control for serious problems in specific crops.

J. Common and scientific names of U.S. agricultural crops.

K. Estimation of losses in corn, sunflower, and grapes from proportion of crop damaged by birds.

# A GROWERS' GUIDE TO REDUCING BIRD DAMAGE TO U.S. AGRICULTURAL CROPS

## INTRODUCTION

Many species of birds have learned to take advantage of man's agricultural activities, particularly the growing of new crops within their range. In some cases, these crops are a replacement for natural bird foods that were present before the land was cultivated. More often they are an important supplement to native foods in the diet of birds. Sometimes these crops, or some stages of them at least, are highly preferred food items. This is because they contain many proteins and fats essential to growth, molt, fat storage, and weight maintenance. Unfortunately for U.S. producers, most crops ripen in the postbreeding season of most U.S. birds, when food demands of bird populations are near their annual peak. Bird numbers are near their annual high at this time, because the young of the year have been recently added to the adult population. The energy reserves of adult birds are minimal and they have a high food demand at this time, because they have just spent long periods in defending breeding territories, laying eggs, and raising their young. They badly need high energy foods to replace feathers molted annually in August and September, and to store fat that will be needed for the annual fall migration of hundreds of miles through regions where foods may not be as plentiful nor weather conditions as favorable for feeding.

The seriousness of bird damage is related to the stage of crop growth. If the preferred stage for a species is the sprouting or ripening crop, then serious damage often occurs; both the period of vulnerability to damage will be long and many plants will be destroyed or damaged as the birds satisfy their daily nutritional requirements. If the preferred stage is the mature crop, then less damage usually occurs. A properly timed harvest puts an end to the damage and the birds are usually welcome to glean crop residuals. When a considerable monetary loss to birds is expected, control methods should be sought for reducing the damage.

Persons most likely to find practical solutions for bird damage problems are those having a good working knowledge of the two main elements involved--the crops being damaged and the birds doing the damage. Agronomists often suggest solutions that involve taking actions against birds that are of little value, and ornithologists often make impractical suggestions to crop producers. The grower, who possesses a knowledge of both birds and the methods available for reducing crop damage, is often the best fitted individual to reduce losses. In this bulletin, an attempt is made to provide growers with the best information on crop-bird relationships existing in 1985.

## IDENTIFICATION OF LOSSES CAUSED BY BIRDS

Before attempting bird control measures, one should make certain that losses are actually being caused by birds. Because birds are fairly large and feed by day, they are usually conspicuous in crop fields, particularly when they occur in large flocks. They are often blamed for lower yields that may be attributable in part or wholely to plant diseases, insects, wind, and, quite commonly, to nocturnal mammals. In a few cases, control of birds has been attempted where the birds were causing no damage to crops, but instead were actually performing a service by feeding on harmful insects. Identification of the bird species causing damage and the proportion that each is contributing to the total is important, since control methods often vary for different species of birds that may be damaging the same panicle of rice or ear of corn. Identification of damage in specific crops is described under sections devoted to control of damage in that crop.

## IDENTIFICATION OF SPECIES CAUSING LOSS

A necessary aid to better crop protection is a bird identification handbook. The United States is fortunate to have excellent field guides for identification of species causing crop damage. Most have color illustrations not only of both sexes but also of immature and adult plumages, e.g., National Geographic Society (1984), Robbins et al. (1966) and Peterson (1947) (Fig. 1). These handbooks can be purchased for less than $10. Pough (1949; 1951; 1957) has authored a 3-volume handbook on bird identification that also contains excellent brief descriptions of their habits, which may enable growers to better protect their crops. Many states have excellent reference books on the birds inhabiting their state and some give substantial detail on their breeding, feeding, and roosting habits. Many species of birds that damage crops are small in size or quite wary, or both, and field glasses or binoculars may be necessary for their identification. Binoculars of 6-power or more are recommended. The most inexpensive are about $30, the better quality about $100, and the best much more. If used often and in wet weather or under dusty conditions, avoid the inexpensive ones.

## IDENTIFICATION OF THE AMOUNT OF LOSSES

Determination of the amount of loss to birds is not an easy task even in an individual field. It requires much effort, and it is expensive to derive countywide, statewide or nationwide estimates. Yet, loss determinations are essential for the development and use of specific methods for alleviating crop losses to birds, both for the growers and for the persons or companies concerned with the profitability of developing and encouraging the use of bird control methods.

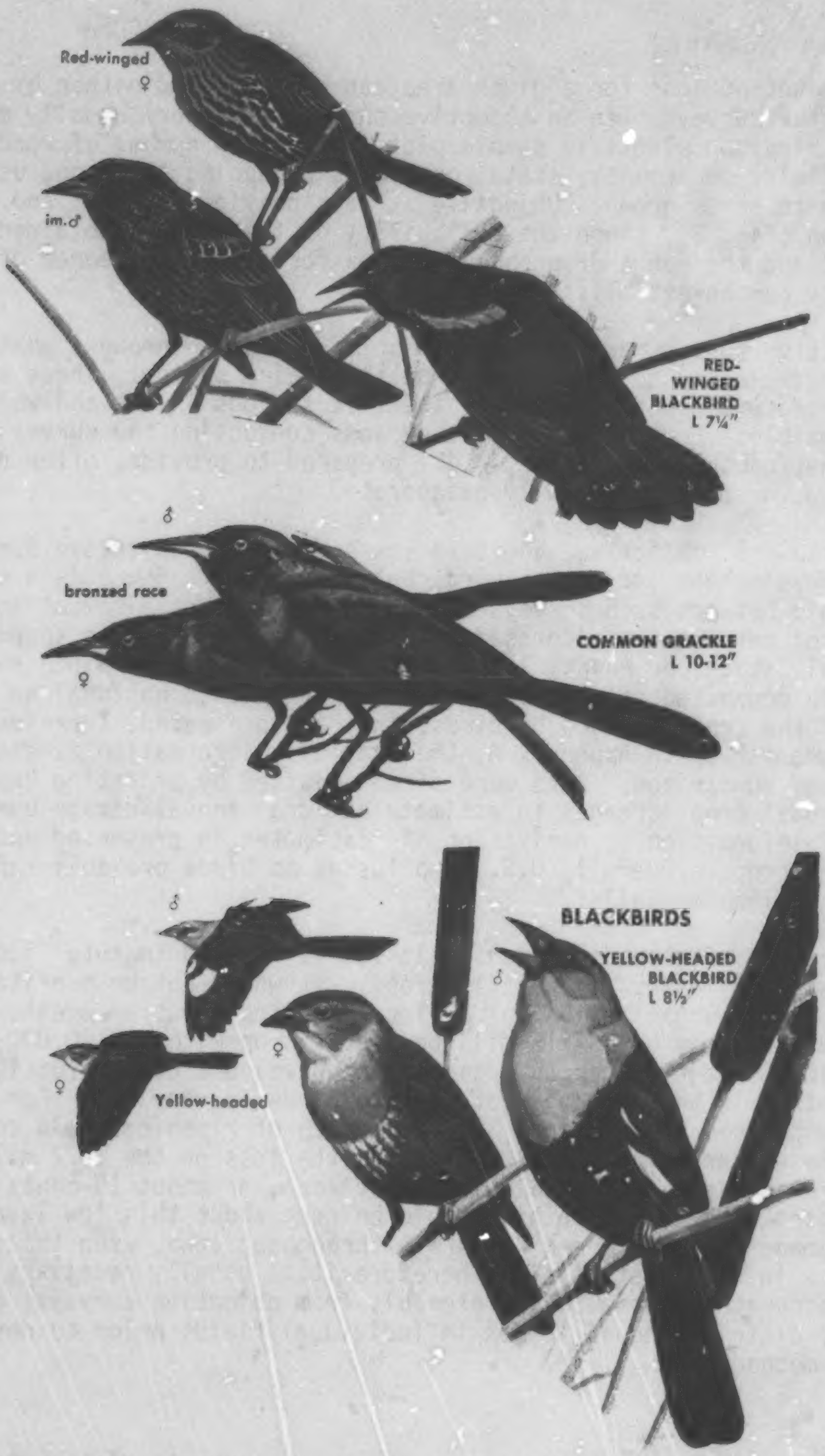

Red-winged
♀
im.♂
RED-WINGED BLACKBIRD
L 7¼"
♂
bronzed race
♀
COMMON GRACKLE
L 10-12"
♂
BLACKBIRDS
YELLOW-HEADED BLACKBIRD
L 8½"
♂
♀
♀
Yellow-headed

Fig. 1. The Red-winged Blackbird, the Common Grackle, and the Yellow-headed Blackbird are responsible for most bird damage to ripening corn and sunflower in the U.S. ( Illustration by author Singer from "Birds of North American" by Robbins et al, 1966, (C) Western Publishing Company Racine, WI.

The amount of loss for a given area can be estimated either by objective or subjective surveys. In an objective survey, assessors usually measure losses to birds on plants in sample plots in a given number of randomly selected fields per county, state, or states producing the crop, usually in proportion to acres grown. Objective surveys provide the best and most usable information (Fig. 2), since the reliability of the numbers obtained can be determined and the range of probable losses for any given degree of reliability can be established.

Subjective surveys are usually conducted by asking growers what they believe their losses to birds are--a questionnaire survey. These surveys are useful for determining locations of the most serious losses and which species are responsible. However, often the persons conducting the survey ask growers for information that the grower is ill prepared to provide, often does not really know, or may purposefully exaggerate.

Nevertheless, objective, and to a lesser extent, subjective surveys are vital to development and use of bird control methods. There is a close relationship between such surveys and the successful development and use of bird control methods, as witnessed by the estimated losses in specific crops at national, state, or county level (Appendix A; Fig. 3). Since there has been little organized effort to systematically conduct national or state-wide surveys of the crops damaged by birds, the data presented, therefore, are often fragmentary. In Appendix A, the available information is cited, notated, and summarized. Data were often adjusted by prorating known damage rates to total crop acreages to estimate national annual damage by crops. Additional information on derivation of estimates is presented under sections on specific crops. Overall, U.S. crop losses to birds probably range from $100-$150 million annually.

Development of methods to reduce losses is related to total losses and to the intensity of losses in specific crops. It would not be profitable, for example, for any organization to develop a chemical control agent, whose development cost may be $5-$15 million, for a crop with a $100,000 annual national loss. Neither can an organization develop a cost-effective damage control method if the intensity of loss to birds is very low. For example, Iowa was estimated to have lost $775,000 worth of ripening field corn to birds in 1981 (Besser and Brady 1982). However, the loss on the 13.7 million acres grown there averaged only 0.06 bushels per acre, or about 15 cents worth of corn per acre. Obviously nothing could be done about this low level of average damage if it occurred uniformly throughout Iowa, even though total losses were indeed substantial. Therefore it is usually necessary to have somewhat accurate information, preferably from objective surveys, on the extent and distribution of losses in individual fields prior to development of a control method.

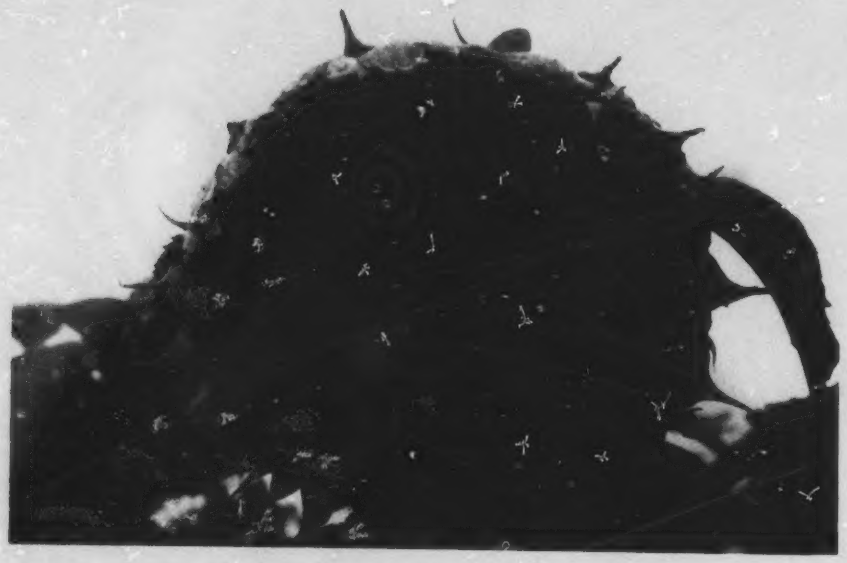


Fig. 2. In objective surveys, bird losses are determined on plants in sample plots. This sunflower head in a sample plot was assessed as having 48% of the seeds consumed by blackbirds. (Photo by the author)

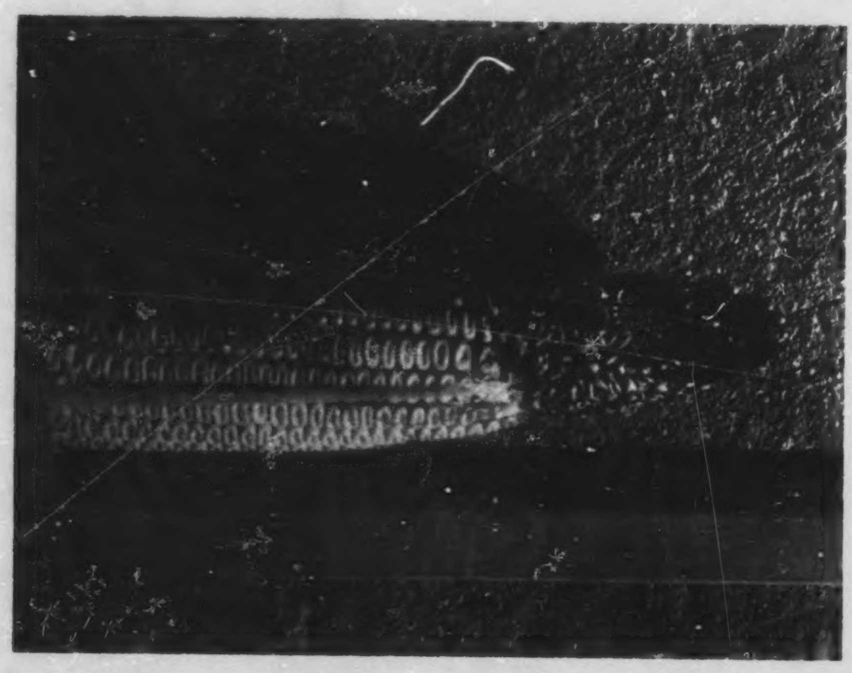


Fig. 3. A close relationship exists between accurate assessment of nation-wide losses to birds in a specific crop and successful development of control methods. Bird damage to ripening corn was objectively determined in 1970, 1971, and 1981 by measuring length of damage and length of ears in sample plots in randomly selected cornfields in 10 to 24 major corn-producing states. (Photo by John W. DeGrazio)

From the growers' viewpoint, it is necessary to have an accurate estimate of losses on one's field (or fields) to properly determine the course of action needed to reduce the damage. One option available to the grower is to do nothing, and indeed, in instances of light damage, this may be the most profitable course to follow. Very low levels of crop damage simply can not be economically combated. At higher levels of damage, some methods may be cost-effective, and others may not be.

Three methods of estimating losses are available to the grower. These are: (a) estimating bird numbers in a field at the time of damage and having information on the maximum potential of an individual bird to damage that crop, (b) estimating losses by checking the most severely damaged portions of a field, and (c) estimating losses by checking the proportion of the crop being lost on all areas of a field.

Few growers can afford the time required to accurately estimate the amount of loss occurring, nor is information available at present to convert numbers of damaging birds seen to maximum potential loss for many kinds of crops. Available damage capabilities for some specific birds and crops are listed in Appendix B. Observations of crop fields for damage and identification of the species responsible pay dividends for the time the grower invests, and often lead to the selection of the best method of control. A better use of time for the grower is to check portions of the field where damage has been most severe in previous years. While making this check, one frequently encounters birds at close range in the act of damaging the crop. At the same time, one is sometimes able to both reduce the damage by applying a control measure and roughly estimate loss for the most heavily damaged area of the field.

The best way to measure loss in a field (or fields) is visit all portions of a field and gather information in a systematic manner--an objective assessment. Neff and Meanley (1957) found "growers estimates of damage to ripening rice were quite accurate for the areas of the field most heavily damaged, but were greatly overestimated for the field overall." This was perhaps due to having visited only the areas of highest damage. A systematic method for conducting an objective survey of a field is to visit random points with in a field and visually assess the damage in terms of a value that can be easily determined by the grower. Examples include the proportion of ears of corn opened, of sunflower heads damaged, of rice panicles with kernels missing, or of bunches of grapes with missing or damaged grapes. Tables are available to convert this information into loss estimates for a few crops and are being developed for others (see information on specific crops).

A major problem in accurate assessment of losses by growers is selection of random sampling points. In view of both the need for this information and escalating travel costs for professional assessors, it appears timely to enlist the aid of growers in these surveys, both for their use and for the use of organizations that could help develop new methods to reduce losses.

A table of random numbers is used by all professional assessors to choose sampling points. Such a 2-digit table is provided for grower use (Appendix C). Digits from this table should be copied for field use. A pencil and notebook are the only other items required (a clipboard is also handy). It is important to check every portion of the field in an objective assessment. For example, in a corn or sunflower field, a reasonable estimate can often be obtained with one plot for each 100 rows and 100 paces of a field. The assessment can be started at any convenient corner of a field. The first random point is established by randomly selecting two 2-digit numbers. This may be done by closing your eyes and pointing a finger at a number in the table in Appendix C. For example if you point to the 49th number (79), the 2 random numbers are 79 and 10. Then by assigning rows and paces to these numbers, the first random point is Row 79, Pace 10; the first plot to be assessed has its starting point on Row 79 and Pace 10 (10 of the assessor's paces into the field). At this random point, select a convenient plot size, one that will take less than 1 minute to assess, for example, 10 ears of corn, sunflower heads, rice panicles, or bunches of grapes. One should determine the proportion of bird-damaged units, for example, 2 of 10 ears of corn. With this measurement, in about 3 minutes, one has objectively and fairly accurately assessed the incidence or frequency of damage on a block of about 1.4 acres of crop (given 30-inch rows and a 33-inch pace).

To assess the second 1.4 acres, obtain the second set of random numbers from the table, the third and fourth numbers in this example, 30 and 69. Since the first two digits have been designated as rows and the second two as paces, and one must enter the next block, add 100 to the number of paces. This gives Row 30 and Pace 169. Since one is at Row 79, Pace 10, by returning 49 rows (to Row 30) and going 159 paces (to Pace 169) farther into the field, one arrives at the random point of the second 1.4-acre sample. Paces are added in increments of 100 to reach additional sampling points until the random point falls out of the field. To return to the edge of the field from which one started, add 1 to the row column and decreasing numbers from 9 to 0 to the pace column. When a point within 200 rows of the starting point is reached, one will have assessed damage in 200 rows of the field (or in 30.3 acres if rows are 30 inches apart and 1/2 mile long). For larger fields repeat the procedure adding row numbers in increments of 100 to the last row number used. Although the procedure appears complex, it is relatively simple, requiring about 1 hour for an experienced assessor to enumerate losses on 30 acres, or about 2 minutes per acre assessed. An assessment, such as this in heavily damaged corn and sunflower fields, has been shown to have accuracies within 18% of that obtained on a second assessment.

Gathering objective information on a crop will be worth the time of the individual gathering it and if pooled with that of other individuals will enlist the efforts of interested organizations in developing suitable control methods for protecting crops from bird damage. The Denver Wildlife Research Center, U.S. Fish and Wildlife Service, Denver, Colorado, 80225, the organization which has led research efforts in protecting crops from birds in the United States for the past two decades, will serve as a clearing house for objective crop damage survey information.

## LEGAL STATUS OF CONTROL OF PROBLEM SPECIES

The proper federal and state permits, if needed, should be obtained before attempting to control birds damaging crops. The legal status of scaring or killing all species of migratory birds according to federal laws is given in a federal publication (Title 50, Code of Federal Regulation) available free of charge from the U.S. Fish and Wildlife Service, Washington, D.C. 20240. A synopsis of these laws pertaining to individual species is given in Appendix D. Briefly, Federal permits to scare birds are required for only a few very rare birds (endangered or threatened species). Federal permits to kill birds are required for all but about 30 species, which may be killed when "in the act or about to commit crop depredation" (See Appendix D). Federal killing permits are not required for House Sparrows, feral Rock Doves (pigeons) and European Starlings (three introduced problem species) and for other undesirable non-native introduced species (see Appendix E for scientific names). State laws on scaring or killing birds damaging agricultural crops are sometimes more restrictive than federal laws. Growers should consult their state wildlife conservation agency before scaring or killing birds. The local Wildlife Conservation Officer is an excellent source for this information.

## METHODS AVAILABLE TO REDUCE DAMAGE

Methods for reducing bird damage to agricultural crops can be placed in four broad categories: (a) cultural, (b) ecological, (c) mechanical, and (d) chemical. A variety of methods under each of these categories are listed in Appendix F. Cultural and ecological methods should be considered first and are discussed in detail under specific crop headings. Mechanical and chemical methods are necessary when cultural and ecological methods fail to alleviate damage sufficiently or are not feasible. Sources of supply for the specialized mechanical devices listed in Appendix F are given in Appendix G. Registered chemical agents for specific crops and birds causing damage are listed in Appendix H. Several of the chemical crop protection agents are restricted to persons trained in their use and certified as Restricted Use Pesticide Applicators by state or federal agencies. One should contact their county agricultural agent for training and certification in the use of these products. Growers are cautioned to use only registered products and follow label use instructions and safety precautions. The most effective mechanical and chemical means in reducing bird damage for specific crops are discussed under specific crop headings.

The grower should consider all methods available for a particular problem and choose one or more that are likely to be most effective and profitable for the situation. Methods available for consideration are heavily influenced by their costs in relation to damage levels and per acre crop values. A list of methods that have been most effective, economical, and safe for use on various specific crops is given in Appendix I. To keep up-to-date, information on the most current methods to protect crops from bird damage is usually available from the Wildlife Specialist, Animal Damage Control, USDA Agricultural Extension Service, whose office is usually at the state agricultural university, or from the State Supervisor, Animal Damage Control, U.S. Fish and Wildlife Service, whose office is usually in the Federal Building in each state capital.

## SOME GENERAL CULTURAL PRACTICES FOR REDUCING BIRD DAMAGE

Several cultural practices for reducing losses to birds apply to nearly all crops. If possible, avoid planting vulnerable crops near breeding, roosting, and loafing cover preferred by the species causing damage. If impractical to avoid planting adjacent to such preferred habitats, timing plantings so that the sprouting and ripening periods are in synchrony with other plantings in the locality lessens the vulnerability of that planting to birds. Crops that sprout or ripen before others in a locality are more susceptible to heavy damage from assemblages of local breeding birds; crops that ripen very late are often severely damaged by migrating birds. Leaving crop stubbes for birds to glean as alternate food sources also lessens damage in unharvested crops. In tilled crop fields, delaying tillage until other vulnerable crops have been harvested provides sources of waste grain and weed seeds that furnish birds with a part of their diet that is not a marketable crop. Finally, harvesting the mature crop as soon as practical always lessens damage from birds that prefer the mature crop stage, and also lowers weather-related losses.

## REDUCING BIRD DAMAGE TO SPECIFIC CROPS

The reduction of bird damage by cultural, ecological, mechanical, or chemical means can best be discussed in reference to specific crops. Crops are discussed, generally in a descending order of estimated monetary losses. Scientific names of the agricultural crops mentioned are given in Appendix J.

## GRAINS - ROW CROPS

### CORN

Corn was planted on 82 million acres (22.5%) of the 363 million acres planted to the 19 major U.S. agricultural crops in 1982 and ranked second in acreage (Statistical Reporting Service 1983a). Damage to corn accounts for the largest national monetary bird loss. Bird damage to ripening field corn was estimated at $20.2 million in an objective survey of the 10 major corn producing states in 1981 (Besser and Brady 1982) (Fig. 4). An additional $14.6 million loss was estimated for 31 states growing corn that were not surveyed. The extrapolated nationwide loss of ripening corn in the U.S. in 1981 therefore was $34.8 million. At the average price for corn from 1973-82 this is a $32.8 million annual loss (Appendix A).

Objective surveys of sprouting corn losses to birds have been conducted only in Virginia, Kentucky, and Tennessee. Losses of 1.6% of the crop were estimated in Virginia in 1971 (Brady and Eggborn, unpublished data, 1971), 0.15% in Kentucky in 1978, and 0.95% in Tennessee in 1979 (Heisterberg 1984). In these three states, estimated losses to birds averaged 0.45 bushels per acre at harvest and cost growers $1.10 per acre based on the average corn price from 1973 to 1982 (Statistical Reporting Service 1983b). These three States, however, are among those believed to have the highest losses nationally. If losses of sprouting corn in the 84 million acres planted in the U.S. in 1982 were 10% as heavy as the losses in Virginia, Kentucky, and Tennessee in the years surveyed, national losses would have totalled $9.8 million at the average 1973-82 corn price (Appendix A). However, this is much less than the $19.9-80.0 million range (at the 1973-82 average price) estimated in 1971 in a questionnaire survey of wildlife and agricultural specialists in 25 states (Stone and Mott 1973).

As with sprouting corn, good estimates are not available for the value of birds losses in ripening sweet corn. In a grower survey in 1966, Maryland estimated sweet corn losses to birds at $456,000 or $15.60 per acre (Anonymous 1967). In a 1970 survey of bird damage to field corn, losses to birds in 18 other States were only 27% as high as in Maryland and the number of ears opened by birds in field corn in Maryland was 3.6 times the national average (Stone and Mott 1973). Therefore, if losses in other sweet corn growing areas in 1978 (the most recent year for which figures are available) were 27% of Maryland losses in 1966, national losses would have totaled about $6.1 million in 1978, at the average price for sweet corn from 1973-82 (Appendix A).

If one combines the annual losses of sprouting and ripening field corn and sweet corn estimated previously, these total $48.7 million at the 1973-82 average price.

## Sprouting Corn

Bird damage to sprouting corn is caused chiefly by the Common Grackle, Common Crow, and the Ring-necked Pheasant (Stone and Mott 1973). The Red-winged Blackbird, Boat-tailed Grackle, Great-tailed Grackle, Fish Crow, Common Raven, Canada Goose, and the Sandhill Crane are other species that also damage sprouting corn.

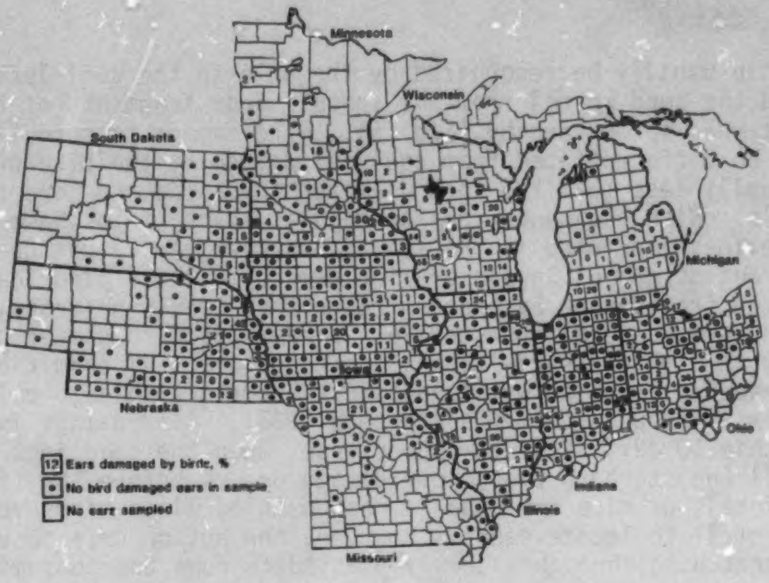

Minnesota
Wisconsin
South Dakota
Michigan
Nebraska
Iowa
Ohio
Indiana
Illinois
Missouri
12 Ears damaged by birds, %
● No bird damaged ears in sample
No ears sampled

Fig. 4. In an objective survey of the 10 major corn-producing states in the U.S. in 1981, loss of ripening corn to birds was estimated at 7.7 million bushel, and at 13.4 million bushels for the U.S. The above map depicts the percent of ears damaged in the counties surveyed in 1981. (Illustration by the author)

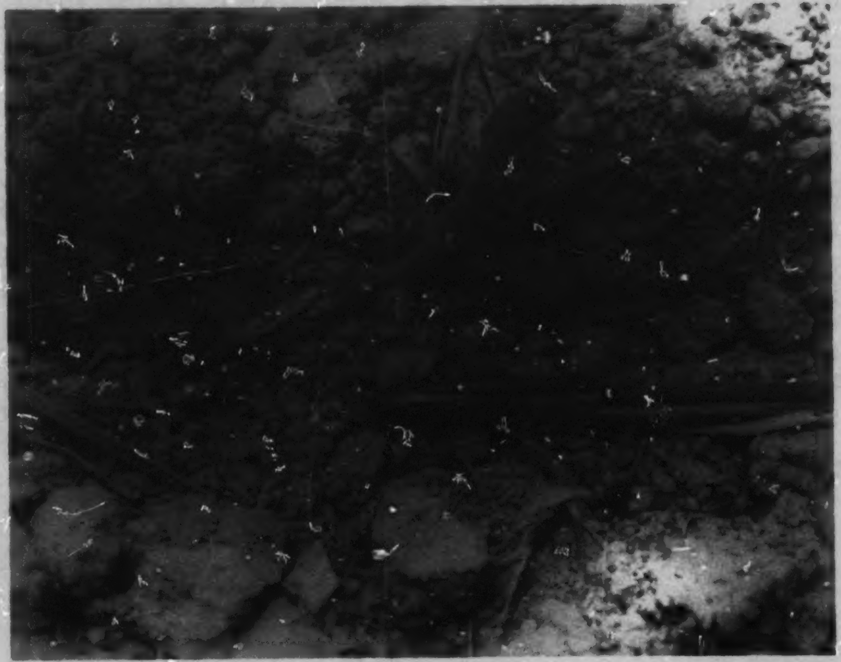


Fig. 5. Bird damage to sprouting corn, such as this seedling destroyed by a grackle, can usually be recognized by the hole left where the bird removed the seed kernel and from the discarded sprout nearby. (Photo by Jon F. Heisterberg)

Damage can usually be recognized by the hole in the soil left where the bird removed the seed kernel from the sprout, from fragments of the seed coat, and the discarded sprout nearby (Fig. 5). Bird damage to sprouting corn usually can be differentiated from squirrel damage by the size of the hole, which is usually less than 3/4 inch diameter for birds and more than 3/4 inch for squirrels. With pheasants, the triangular shape of the base of the lower bill is sometimes imprinted in the soil. Grackles and Canada geese sometimes clip the sprout at ground level; grazing damage by these birds can often be differentiated from damage by grazing rodents by tracks or droppings. However, many grazed seedlings survive. Birds appear to damage sprouting corn more heavily in lighter (sandy) soils and under wet soil conditions. Sometimes, especially under wet conditions, birds are able to pull sprouts by grasping them at ground level (Heisterberg 1983). Bird damage is usually greatest within 10 days after sprouts emerge, when the seedlings are less than 4 inches tall (Heisterberg 1984). If damage occurs before the first sprouts emerge, squirrels or mice are usually responsible, since birds rely upon sight rather than smell to locate seeds. However, the author once observed pheasants scratching throughout newly planted furrows and consuming unearthed kernels. Hen pheasants, perhaps older and more experienced than the heavily hunted cocks, appeared to do most of the scratching.

The amount of damage an individual bird can cause in a sprouting cornfield is surprising. West (1968a) estimated that five pheasant cocks in a South Dakota cornfield destroyed 7,160 corn plants, or the equivalent of about 10 bushels of harvestable corn per bird. In Minnesota, Fried (1940) reported that 3.3% of the June diet of pheasants collected throughout the state was sprouted corn. Even at this low consumption level per bird, a pheasant in Minnesota could have cost growers an average of $5.10 (at current prices of harvestable corn) in the month of June, if none of the sprouted corn was waste corn and no compensatory growth from adjacent corn plants occurred. In an Iowa study in 1976, 12% of the plants were destroyed within a 1-acre area in the center of a territory of each cock pheasant (Besser 1976). At 1982 yields and prices, this cost growers $14.80 per breeding cock, if no compensatory growth in the stand occurred. An individual grackle, weighing only about 1/10 as much as a pheasant, also can inflict a surprising amount of damage to a sprouting cornfield. In cage tests with unearthed corn sprouts, adult grackles damaged an average of 32 sprouts in a 3-hour period (Heisterberg and Otis 1983). A 22-acre cornfield was nearly completely destroyed in South Carolina by breeding Common Grackles and the greatest number of grackles observed during a 4-day period was 123 (Guarino 1967). In Delaware, grackles damaged two corn sprouts per minute per bird (Rogers and Linehan 1977). At this rate, a dozen grackles feeding in a sprouting cornfield would cost a grower 39 cents per minute at harvest, based on the 1973-82 average price, if no compensatory growth occurred.

## Protection of Sprouting Corn

The cultural practice most likely to reduce bird damage is deep planting. Corn seeds planted more than 2 inches deep suffered less grackle damage than shallower planted seeds (Heisterberg 1983) and corn planted more than 3 inches deep in clay soils in Iowa suffered no losses in spite of a high population of pheasants feeding in the field (Besser 1976). Tillage to obtain a clean seed bed may also be helpful; fields with debris from previous corn crops and with many weed seeds are more heavily damaged by grackles than clean fields (Heisterberg 1983). A word of caution on completely cleaning fields of crop residues is in order. Breeding birds must obtain food somewhere and the crop residues may actually reduce damage on all fields within the feeding range of a breeding population.

Ecologically, dense stands of even-aged young pines are excellent breeding habitat for grackles and shrub and tall grass field borders make good cover for crowing male pheasants to assemble hen harems. Because effective methods are available to protect sprouting corn from damage by birds, cover thinning is not recommended. Placing of alternate foods, such as trails of shelled corn along field edges, has been recommended for reducing sprout feeding by pheasants, but the food supply must be maintained until sprouts are about four inches tall or else damage may be greater than if alternate foods had not been provided (Dambach and Leedy 1949).

The mechanical means for protecting sprouting cornfields are shooting, scarecrows, and exploders in that order of frequency (Stone and Mott 1973). Shooting grackles and crows and use of exploders were reported to be effective by some respondents to questionnaires, whereas scarecrows were less so (Stone and Mott 1973). Many growers using mechanical means did not obtain effective damage reduction.

Treatment of seed with chemical repellents is favored by many growers for protecting sprouting corn from birds (Fig. 6, Appendix I). Currently, several are available in graphite-containing seed treatments that can be mixed in the hopper box of planters.

Methiocarb is federally registered for use at 3 to 9 ounces of formulated product per bushel (0.17% to 0.50% active ingredient) of seed treated. Products containing methiocarb (Mesurol®,1/ and Borderland® Black) have been highly effective in protecting sprouting corn from birds at costs of $1-$3 per acre. In New York, a variety of birds (mostly blackbirds) damaged 24 times as many sprouts in untreated fields as fields treated with 0.5% methiocarb (Ingram *et al*. 1973). This level was somewhat

---

1/ Use of tradenames does not imply endorsement of products.

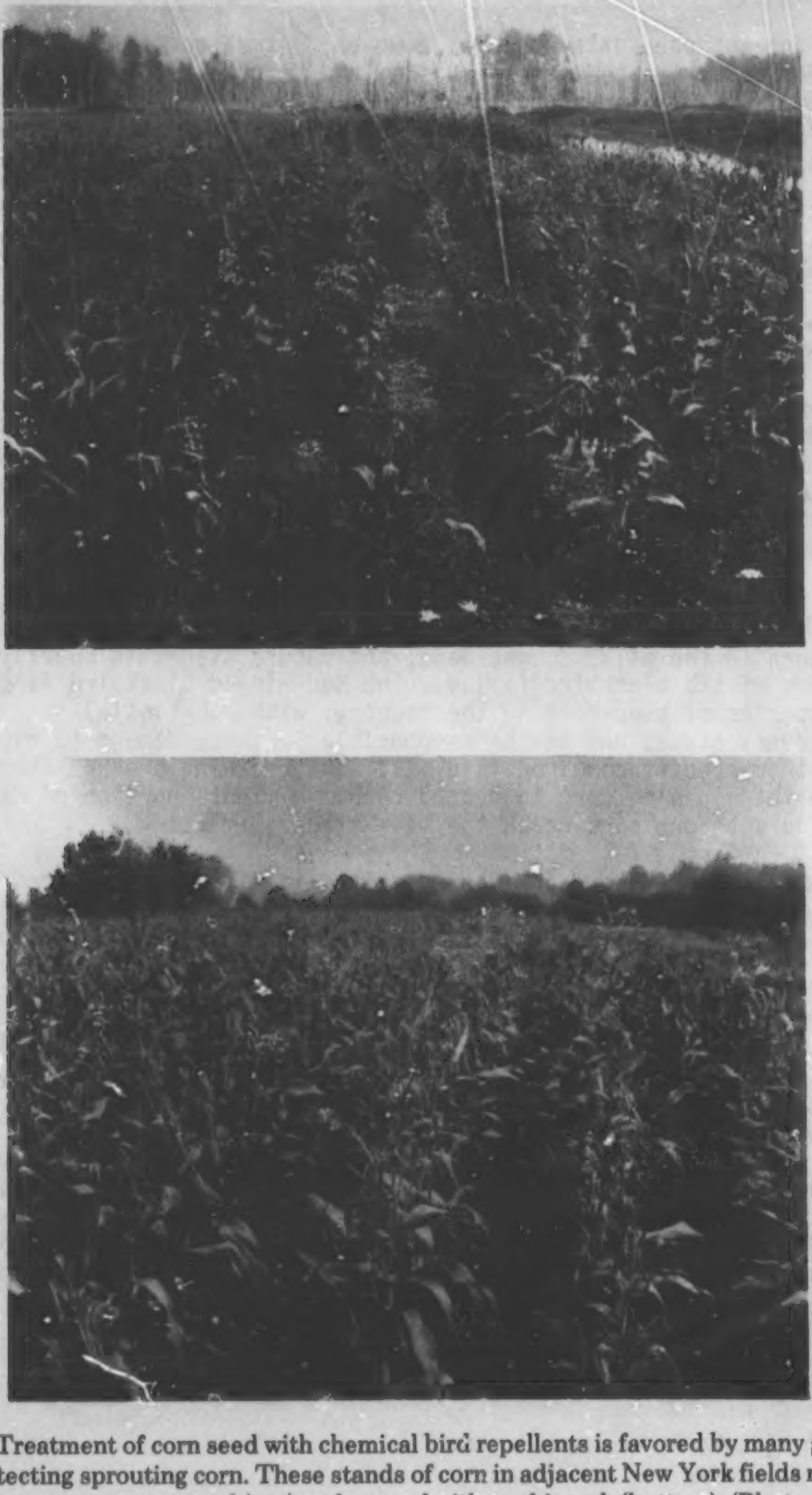


Fig. 6. Treatment of corn seed with chemical bird repellents is favored by many growers for protecting sprouting corn. These stands of corn in adjacent New York fields resulted when the corn was untreated (top) and treated with methiocarb (bottom). (Photos by J.E. Forbes).

less effective against pheasants in Iowa; however, untreated fields had three times as much damage as treated fields (Besser and Knittle 1977). Water slurry formulations of methiocarb, although more difficult to handle than the registered hopper box treatments, proved even more effective. In tests with 0.5% methiocarb in water slurries, 22 times as many sprouts were pulled by pheasants in untreated cornfields as treated fields in South Dakota (West et al. 1969); 3 times as many by Great-tailed Grackles in untreated fields as treated ones in Texas (West and Dunks 1969); 5 times as many by a variety of birds in untreated fields as treated ones in New York (Guarino and Forbes 1970); and 147 times as many by grackles and crows in untreated fields as treated ones in South Carolina (Stickley and Guarino 1972). These levels of protection show that growers could obtain even greater corn protection, if they wished to treat their own seed. The increasing use of high speed air-planters, which tend to lose more of the repellent dust than conventional planters, may dictate use of slurries under some conditions. This author suspects that much lower levels of methiocarb than currently used would provide adequate protection of corn sprouts from most birds under most conditions. Current seed treatment costs make protection of fields with less than 1.0% damage unprofitable.

## Ripening Field Corn

Damage to corn in the milk, dough, dent, and mature stages is chiefly caused by members of the blackbird family. The Red-winged Blackbird is the most numerous species of blackbird in the country, with substantial populations in every state, and may be responsible for more damage to ripening corn than all other species combined (Fig. 7). The red-wing prefers the milk and dough stages of ripening corn to dented corn. A minute portion of damage by red-wings occurs before ears reach the milk stage.

The Common Grackle is second in importance and is widely distributed in all regions of the United States except the West. The Common Grackle, and its close relatives, the Boat-tailed Grackle and the Great-tailed Grackle, both with much more restricted ranges, appear to prefer the dough, dent, and mature stages of corn. The Yellow-headed Blackbird is a distant third in importance, and is a problem only west of the Mississippi River. Like red-wings, yellow-heads prefer the earlier stages of ripening corn. Other birds, with the possible exception of the House Sparrow and Common Crow do relatively little damage to ripening corn. Some species, such as the Starling Brown-headed Cowbird, and Brewer's Blackbird, sometimes associate with foraging flocks of red-wings, grackles, and yellow-heads, but feed mainly on the ground or on ears opened by other species. Blackbird damage always starts at the tip of the ear, and usually on its upper surface. Damage by red-wings and yellow-heads in the milk stage is recognizable by the manner in which they open the ears by slitting the husk into 1/8 to 1/2-inch strips and peeling these back over the remaining kernels. In the milk stage, kernels are punctured and the soft seed coats then quickly dry and are blackened by

Fig. 7. The Red-winged Blackbird (such as this color-tagged male) is probably responsible for more damage to ripening corn than all other species of birds combined. (Photo by J. W. DeGrazio).

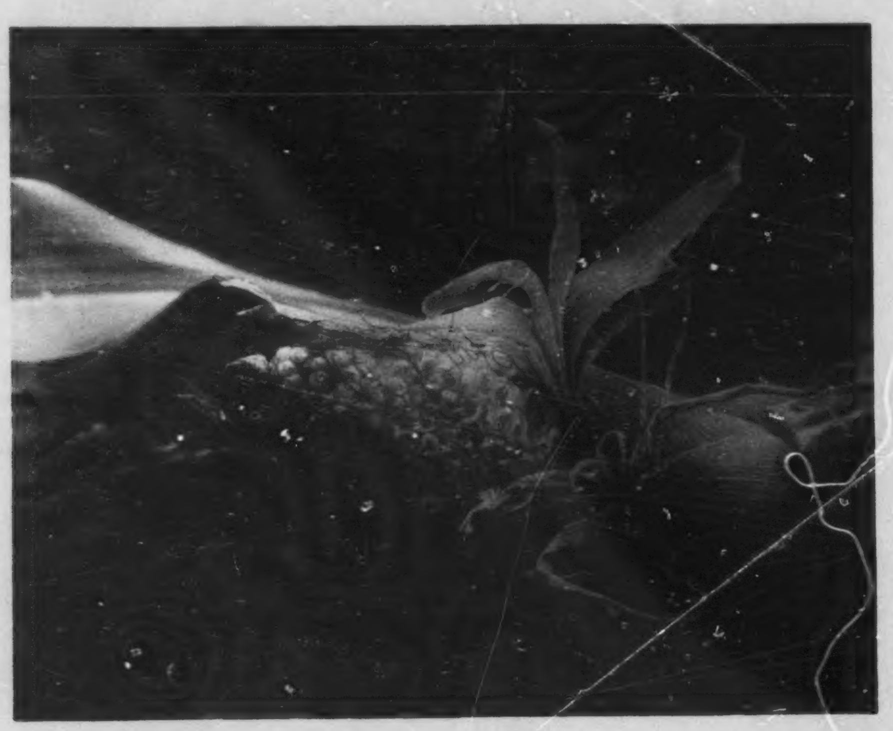


Fig. 8. Blackbird damage to ripening field corn in the dough stage can be recognized by shredded husks and kernels with most of the contents removed, leaving the cellulose seed coats adhering to the cob. (Photo by Jon F. Heisterberg)

fungus. In the dough stages, birds also puncture the kernels and remove most of the contents, but leave the cellulose seed coats of the kernels adhering to the cob (Fig. 8). Grackles also damage kernels in this manner in the dough stage, but more often remove the entire kernel in the mature and dent stage. Mature kernels are also taken by red-wings and yellow-heads but are not preferred. All three types of damage can be seen on some ears. Ears with severe damage resemble a peeled banana with the peel still attached.

The amount of damage an individual blackbird can cause daily is greatest in the milk and dough stages (Appendix B). In cage tests of their consumption capability, adult male red-wings (nearly twice as large as females) damaged 1.4 ounces of milk-and dough-stage corn per day (De Grazio 1965). This is equivalent to about one-half their total weight. Although they consumed only about one-third of the amount damaged, nevertheless the grower suffers this amount of yield reduction. As corn reaches maturity and kernels increase in weight, this level of damage decreases, approaching 1/2 ounce daily or about 10% of the body weight of a large grackle.

For the grower to make a rough estimation of the amount of loss in a particular cornfield to enable the selection of a cost-effective damage control method, the sampling methods noted in the section on identification of amount of loss are appropriate. Conversion of proportion of ears damaged to an estimation of bushel/acre loss can be made by employing the information given in Appendix K.

## Protection of Ripening Field Corn

The cultural practice most likely to prevent severe bird damage at the various ripening stages is to time planting so that the field ripens at about the same time as most other fields in the locality. Planting hybrid varieties whose husks are thicker and completely cover kernels or extend substantially beyond kernels is helpful in reducing bird damage (Mitchell and Linehan 1967; Dolbeer et al. 1982), if that variety ripens at the same time as others in the locality. Instances have been recorded where a field of the long-husk variety received more damage than any other in the locality, when it ripened later than any other (De Grazio 1963). Elimination of weeds or insects sometimes reduces bird damage in a particular field, but these are alternate foods for blackbirds during the period they feed on ripening corn. However, it is doubtful that control of weeds and insects by themselves will reduce damage in all fields within the range of a blackbird roost. It is pertinent that the diet of red-winged blackbirds at the height of the corn damage season in South Dakota cornfields consisted of 41% foxtail or pigeon grass (*Setaria*) and only 27% corn (Mott *et al*. 1972). Control of weeds and insects will increase yields, but is *not* recommended solely for bird damage reduction purposes. Damage was 2.5 times greater in the 10 major corn-producing States in 1981 than 1971 (Besser and Brady 1982) during a period when herbicide use increased 2.4-fold (Delvo and Hawthorn 1983).

Nearly all corn farmers with blackbird problems are aware of the value of frightening birds from cornfields by patrolling them with rifles and shotguns, or by using exploders and pyrotechnics. They also know this activity requires several hours each morning and evening, and occasionally all day. Corn is most vulnerable to birds for approximately 3 weeks--but the most severe damage by red-wings often takes place in about a 1-week period in the early dough stage (Bridgeland 1979). Therefore protection of cornfields by mechanical means is especially profitable during the late milk-early dough stage of ripening.

Persevering farmers can nearly fully protect their crops by patrol. Birds can be moved effectively and economically by firing a round from a .22 caliber rifle above the feeding birds to flush them and then immediately firing a series of rounds behind the departing flock. Since rifle rounds can be hazardous up to 1 mile, good judgment must used.

Use of "shell-crackers",a 12-gauge shotgun shell containing a powerful firecracker instead of shot, is a second effective means for moving flocks of birds. A 12-gauge shotgun launches the firecracker, which explodes above the birds, about 100 yards from the gunner. Blackbirds, from their long association with hawks, instinctively pay attention to things above them. Shell-crackers are far more effective than regular shells for moving birds, and greatly increase the range and versatility of a person patrolling the field. However, the cost of shell-crackers is nearly double that of standard loads. Two or more gunners complement one another in protecting large fields with shell-crackers.

Patrol by aircraft has not been as effective as the foregoing statement about hawks would indicate. Birds often take refuge from the plane in the crop instead of leaving the field, and they are extremely difficult to move from loafing cover, such as shelterbelts, with a plane (De Grazio 1964). In addition, the cost of flying has increased much faster than crop value, making this approach steadily less attractive.

A gunner attempting to kill birds with a shotgun, where state laws permit them to be killed, is one of the least effective and costly of all methods of patrolling.

Gas-powered, propane or acetylene, exploders (Fig. 9) probably have saved more ripening corn from birds to date than any other means. The exploder produces a sound about nine times louder than a shotgun blast. Some exploders have solar cells that turn them on at daylight and off at dark, thus reducing maintenance time. However, for best results, exploders should be moved frequently so that birds do not habituate to them as quickly. One exploder can nearly fully protect about 10 acres of crop, and has beneficial effects over a larger area (Mitchell and Linehan 1967). Mounting the exploder on a stand above the crop gives the best deterrent effect. A small, thin steel drum, with the ends removed, mounted just beyond the barrel of the exploder, will serve as an amplifier and increases the effectiveness of the exploder.

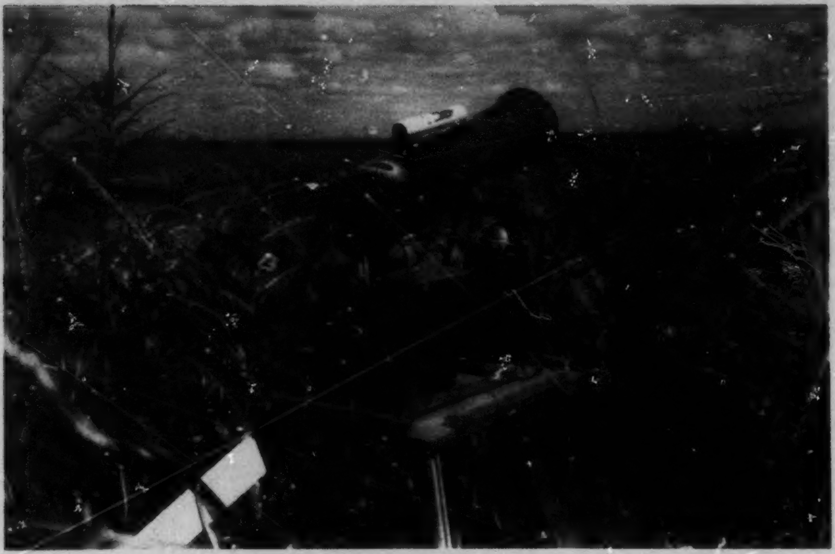
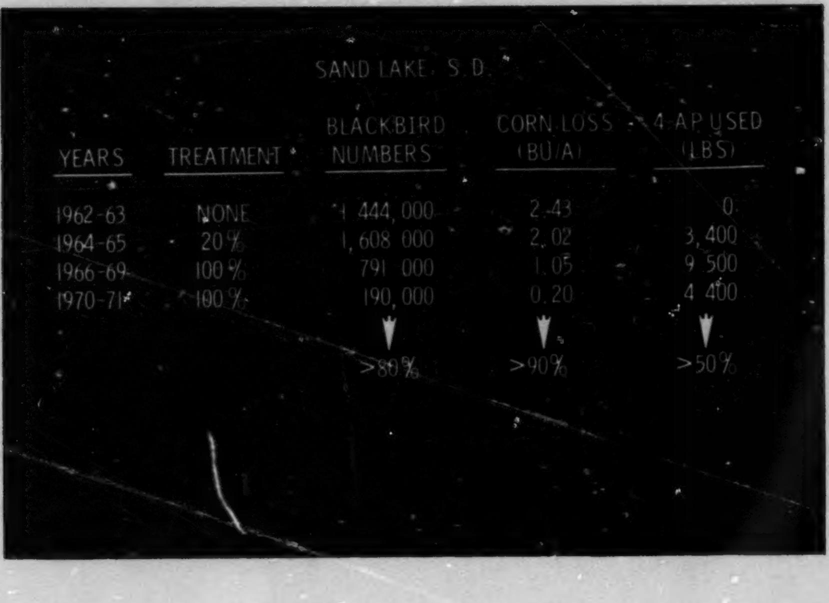


Fig. 9. Gas-powered exploders probably have saved more ripening corn from birds to date than any other means. (Photo by John W. DeGrazio)



SAND LAKE, S.D.

| YEARS | TREATMENT | BLACKBIRD NUMBERS | CORN LOSS (BU/A) | 4-AP USED (LBS) |
|---|---|---|---|---|
| 1962-63 | NONE | 1,444,000 | 2.43 | 0 |
| 1964-65 | 20% | 1,608 000 | 2.02 | 3,400 |
| 1966-69 | 100% | 791 000 | 1.05 | 9 500 |
| 1970-71 | 100% | 190,000 | 0.20 | 4 400 |
| | | ▼ | ▼ | ▼ |
| | | >80% | >90% | >50% |

Fig. 10. Broadcasting baits treated with a chemical frightening agent resulted in an 85% reduction in bird damage in South Dakota cornfields in 1965. (Illustration by the author)

Rope firecrackers are effective for small acreages and short damage periods (Mitchell and Linehan 1967). Flash-salute firecrackers, known popularly as bulldogs, cannon crackers, cherry bombs, or salutes, are used in firecracker rope. The fuses of the firecrackers are inserted at intervals between strands of a loosely twisted cotton rope, one end of which is tied to the apex of a tripod made of wooden stakes. The free end of the rope is ignited, and as it slowly burns, the ignited firecrackers drop from the rope and explode. Timing of explosions is regulated by spacing the firecrackers along the rope. A metal container such as a wash tub should be placed below the smoldering rope, to avoid fires in dry fields and to amplify the sound. Approximately 10 acres of standing corn can be protected with one rope-firecracker assembly (Mitchell and Linehan 1967).

Amplification of recorded distress, alarm, and escape calls of blackbirds and calls of their natural enemies, such as hawks, have been used to protect corn crops. Electronically generated amplified sounds also have been used by some growers. The equipment to broadcast calls is expensive, however, and often requires expert knowledge to keep it functioning properly under the weather conditions prevailing in cornfields. Because of attendant problems, deterrent calls for protecting cornfields have not been widely used. Broadcasting calls from planes also has been attempted in corn crops and found effective, but costs, always high, are becoming prohibitive.

In recent years, mechnical frightening methods have sometimes been replaced by chemical frightening methods. The discovery of a chemical that causes some species of birds to emit distress cries while ascending in erratic flights, often to heights of 500 feet or more, led to a new method of protecting crops--the use of chemical frightening agents (Goodhue and Baumgartner 1965). Birds consuming treated particles are usually killed, but the few affected produce flock frightening response. The ability of one of these agents, 4-aminopyridine (4-AP), to protect crop fields was first demonstrated in cornfields in South Dakota by biologists of the U.S. Fish and Wildlife Service in 1964 (De Grazio et al. 1971). They sprayed partially husked ears of corn with a 4-AP solution at the rate of five ears per each 2 acres of corn per treatment on a grid pattern, and obtained a 78% reduction in blackbird damage in the 1,013 acres treated. In 1965 in this same area, they broadcast chopped corn baits treated with 3% 4-AP that had been diluted with 29 parts of untreated corn at the rate of 1 lb of the diluted bait mixture per treated acre and obtained an 85% reduction in damage (De Grazio et al. 1972) (Fig. 10). The ratio of treated to untreated particles was increased subsequently to 1 to 99 and this product was federally registered in 1972 to protect cornfields from blackbird damage under the trade name of Avitrol$^R$ FC Corn Chops-99 (AFCC-99).

Despite the effectiveness demonstrated in tests that secured registration of AFCC-99 in corn, several problems developed which hindered the most effective use of this product. These problems involved bait stability, professional applicators, lack of concerted and sustained baiting efforts, and improvement of use directions. Most of the problems in application of AFCC-99 should be corrected within the next few years. Then corn growers with perennial bird damage problems should receive the kind of protection against blackbird attack demonstrated in cornfields in Brown County, South Dakota, over a 7-year period from 1964 to 1971 (Besser et al. 1973). In that study, damage in a 94 $mi^2$ study area decreased by 90% (from 2.43 to 0.19 bu/A), blackbird populations in the roosting marshes declined 80% (from 1.6 million to 300,000), and baiting efforts decreased by 50% from the peak use of 9,000 lb to 4,500 lb during the 7 years of study (Fig. 11).

Most past problems with the use of the chemical frightening agent AFCC-99 occurred in the transfer of the agent from experimental to commercial use. First was bait stability. The active ingredient, 4-aminopyridine, has a tendency to dissipate (sublime) at room temperatures, and this process is accelerated at field temperatures (Cunningham 1983), where baits lying on the soil surface may be subject to temperatures as high as 120°F. This problem was minimal under experimental use, where baits were prepared on site 1 to 5 days prior to being distributed in fields. Field clearance of birds damaging corn was often obtained within 3 days of bait preparation. However, under commercial use, the time from bait preparation to field use was commonly 2 weeks or more (and sometimes several months) and baits lost much of their potency before use. The addition of hydrochloric acid to stablize the 4-AP has greatly increased its effectiveness (Besser and Hanson 1983; Besser and DeGrazio 1985).

Secondly, there was a problem in use directions. Based on early studies, growers were regularly advised to apply AFCC-99 in swaths over entire fields, although this was not stated on the label. However, recent studies show that blackbird forays in crop fields nearly always originate from suitable loafing cover (most frequently a group of trees) or roosting cover (most frequently marshes). For example, AFCC-baited and unbaited sunflower fields in Steele County, North Dakota, had 9 and 3 times as much damage, respectively, within 50 yards of the edges as in interior areas (Knittle 1976). Frequent baiting of the more vulnerable portions of fields result in more effective and more economical field protection than less frequent baiting of the entire field. Treating only those portions of the field where blackbirds are causing damage also reduces hazards for nontarget species of birds that also feed in crop fields. Obviously, if the portions of a field in which blackbirds seldom or never feed are baited, one will kill a greater proportion of (or only) nontarget individuals. Growers trained in the use of this frightening agent now are able to treat those portions of their field where damage control with this agent is profitable. Since the cost of bait for a single application has increased to $1.15 per acre in 1985 (professional applicators often double

Fig. 11. More than 80% protection has been obtained by baiting cornfields with a chemical frightening agent. (Photo by J.W. DeGrazio)

Fig. 12. Farmers being instructed in protecting cornfields from blackbird damage by broadcasting baits treated with a chemical frightening agent from high-clearance tractors equipped with electric seeders. In 1966, 54 farmers protected corn in a 508 square mile area in South Dakota. (Photo by Lyle Schoonover)

this price), clearly the product needs to be used more effectively and to be made available to growers through more direct local channels. From one to five baitings are normally needed to protect a field depending upon the amount of damage and the distance of the field from the roosting and loafing areas of blackbirds. Certification of growers under the new pesticide regulations being formulated by individual states is important in obtaining a concerted baiting effort. In 1966, 54 farmers in Brown County, South Dakota, were allowed to purchase baits and they applied them effectively and safely without the aid of aircraft, and protected cornfields in a 508-square-mile area (De Grazio et al. 1966) (Fig. 12). These 1966 results and those more recently obtained cause the author to list chemical frightening agents as the preferred method of damage control for ripening field corn (Appendix I).

Thirdly, there is a problem of field accessibility for baiting. One who has walked a cornfield knows the degree of effort involved. The difficulty was increased when narrower rows and increased fertilizer rates, created even denser foliage. Growers with perennial bird problems are advised to leave single rows unplanted (baiting lanes) at 55-row intervals (starting 24 rows from the edge of a field) to enable the passage of a person scattering AFCC-99 baits by hand or from a small tractor or all-terrain vehicle. These lanes should also increase the effectiveness of baits distributed by aerial applicators. Removal of corn plants on 1/55 of the field to form baiting lanes does not result in a 1/55 reduction in the yield of a field. In Minnesota in 1976, reduction in corn plant populations from 20,000 to 10,000 per acre resulted in decreased yields of only 6% at a site with adequate moisture (DeLoughery and Crookston 1979). However, of special interest to growers contemplating establishing baiting lanes, 10,000 plants per acre outyielded 20,000 plants per acre by 32% when growing conditions were very dry.

In 1983 and 1984 studies were conducted in Brown County, South Dakota, in which AFCC-99 baits, stabilized with hydrochloric acid, were broadcast from baiting lanes created when plants were small. Baits were applied with an electric seeder mounted on an all terrain cycle (Fig. 13). In 1983, six baited fields lost 25 bushels of corn during a 6-day period, when fields were most vulnerable to damage, whereas a 312-bushel loss was expected based on damage to untreated fields, or 92% less than expected (Besser and Hanson 1983). In 1984, bird damage in 12 fields was reduced 87 percent during 2-week baited periods compared to 3-day pre-treatment periods; 19 bushels of corn per day were lost during baited periods, whereas 142 bushels per day were lost during pre-treatment periods (Besser and DeGrazio 1985). About 100 acres of field per hour were baited at an estimated time and equipment amortization cost of less than 15 cents per acre per application. Benefits of baiting were calculated to be more than $5 for each $1 spent for bait and loss of corn yield in baiting lanes. Growers in this situation would have saved about $400 worth of corn for each hour spent creating lanes and baiting. Lower baiting rates and leaving baiting lanes unplanted may further improve cost-benefit ratios.

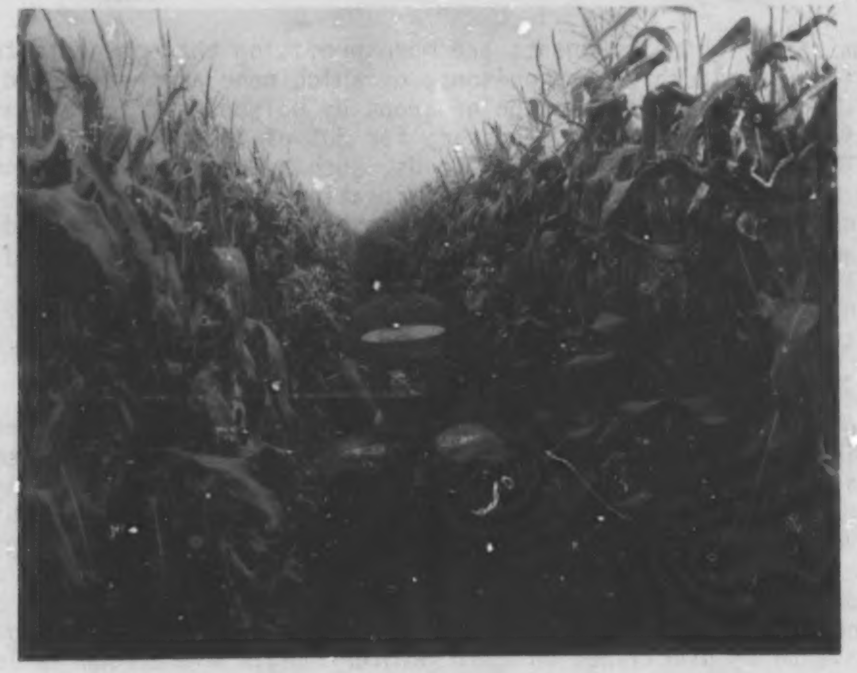


Fig. 13. Application of stabilized 4-aminopyridine baits on baiting lanes with a seeder mounted on an all-terrain cycle proved both economical and efficient. About 100 acres per hour could be baited with the above unit. Unbaited fields lost 12 times as much ripening corn to blackbird as baited fields (Photo by the author).

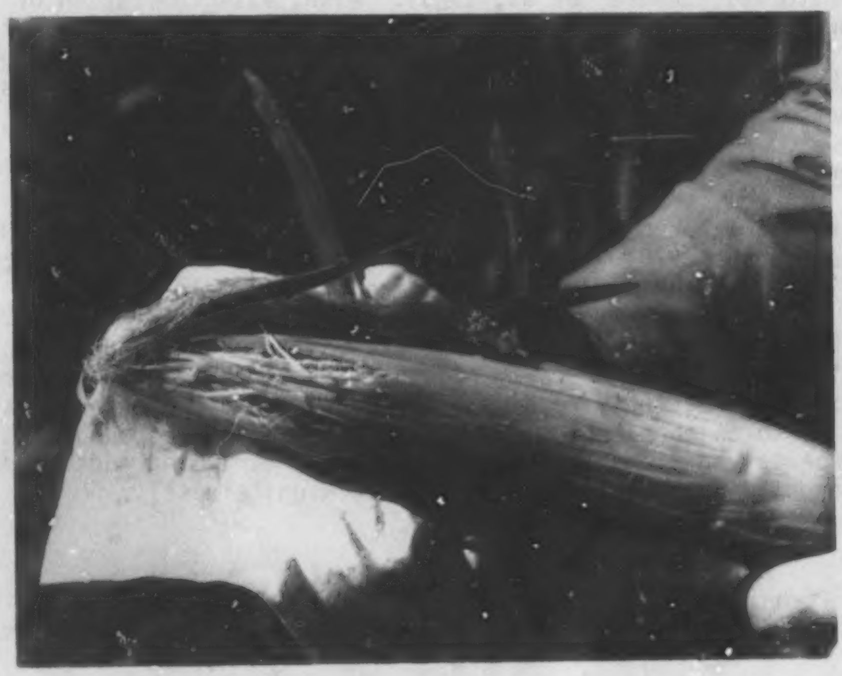


Fig. 14. Husks of sweet corn ears are less tight than on field corn ears and are more easily slit on the sides by blackbirds. (Photo by Charles P. Stone)

Chemical frightening agents are more promising than attempts to reduce populations of blackbirds by poisons, of which none are registered for use in crops. To obtain 80% protection of crops by poisons--a figure that would be a realistic goal--it would be necessary for 80% of the offending birds to ingest bait. The competition with other foods, such as ripening corn, and the short stay of blackbird populations during migration probably makes this figure unattainable, even by persons with the most knowledge of blackbird feeding habits and preferences. However, 80% protection has been obtained with the chemical frightening agent 4-AP (Fig. 12)--by affecting less than 1% of the offending blackbird population--a figure that has been obtained by persons with little knowledge of blackbird feeding habits and preferences.

Other chemical methods for protecting ripening corn also have disadvantages. Repellent sprays, which show good potential for protecting other kinds of crops, appear to have little potential for use in corn, since the spray falls on the husks, preventing the chemical from reaching the kernels. Chemosterilants--birth control agents for blackbirds--which could effectively reduce production of young and largely negate breeding habitats, might be profitably employed. However, sterilization of the bird populations involved in the major portion of corn damage areas will require a better knowledge of bird movements than anyone presently possesses. Birds probably would have to be sterilized on their winter ranges where food is less plentiful, or in spring roosting assemblages of male blackbirds, such as the one noted near Mound City, Missouri, which was composed of several million adult male red-wings (West and Besser 1967). This task would be formidable and expensive, and would require federal registration of a suitable chemical. In laboratory and pilot field studies, certain chemicals permanently sterilized male red-wings and did not affect their ability to successfully hold territories (Schafer et al. 1976). Also, vasectomization of red-wing males lowered production of young on breeding territories (Bray et al. 1975). However, chemosterilant research on birds now has a low priority within the U.S. Fish and Wildlife Service, pending the outcome of programs using more direct methods of protecting crops.

## Sweet Corn

Sweet corn was grown on 674,000 acres on 33,000 farms in the U.S. in 1978 (Bureau of Census 1978). Fifteen states grew more than 10,000 acres of sweet corn in 1978. Blackbirds prefer sweet corn over field corn.

Blackbirds are perhaps capable of causing more damage daily to sweet corn, sold as "roasting ears" in fresh produce markets, than to any other maturing crop. Growers frequently receive 5 cents per ear or more for "roasting ears." Bird damage to sweet corn for canning is less serious because lightly damaged ears can be salvaged, but the time required for trimming ends of damaged ears also makes bird damage to cannery sweet corn quite costly.

The Red-winged Blackbird is the species responsible for most damage to sweet corn. The Common Grackle causes much of the remainder. Starlings have been reported to feed on sweet corn, but largely feed on ears opened by red-wings and grackles.

Bird damage to sweet corn is nearly identical to that for field corn, except that damage does not always begin at the tip (Fig. 14).since sweet corn husks grow more loosely and are more easily slit on the sides. Birds searching for earworms (Heliothis zea) sometimes slit many husks in the silk area above the sweet corn kernels (Mott and Stone 1973b). In assessment of damage to ears of corn for the fresh produce market, damage incidence is equal to whole ear loss; for sweet corn sold to canneries, the table developed for field corn is appropriate for gauging losses (Appendix K).

## Protection of Sweet Corn

Timely harvest is the cultural practice most likely to reduce bird damage. In an Ohio study, bird damage in 12 test fields increased from 1% at the fresh market harvest date to 26% at the cannery harvest date, 5 days later (Stickley and Ingram 1977). If growers with perennial blackbird problems have the option, they would receive less damage if they grew corn for the fresh market than for the cannery market, and less if they grew corn for cream-style than for whole-kernel cannery use. Ecologically, locating sweet corn fields as far as possible from marshes and wooded areas, especially wooded stream courses, aids in reducing bird damage.

The mechanical scaring devices that are effective in field corn are even more effective in sweet corn, because of the shorter (5 to 10-day) protection period for the latter crop. This circumvents much of the habituation that occurs in the use of scaring devices for protecting field corn, where a field may be vulnerable from 3-5 weeks. The higher value of sweet corn acreage also allows the more cost-effective use of a greater number of scaring devices for sweet corn than field corn.

AFCC-99 has also been more cost-effective in sweet corn than field corn because of the shorter protection period. In Wisconsin, damage was 10 times greater in 14 untreated fields than in 14 fields baited with 4-AP (Knittle *et al.* 1977). Protection was greater in Wisconsin than in studies in four other states where bird numbers were lower (Dolbeer *et al.* 1976), indicating 4-AP is most effective and economical where damage is most severe.

Repellent sprays of methiocarb for protecting sweet have been tried with the thought that if birds were primarily seeking insect foods in sweet corn fields, then killing the insects (with methiocarb) might reduce damage. The initial study in Ohio using two treatments of 1.5 lb of methiocarb appeared encouraging (Stickley and Ingram 1977), but an attempt to repeat the degree of protection originally indicated was unsuccessful (Stickley and Ingram 1979).

The use of an insecticide to reduce damage to sweet corn by blackbirds has been advacted in Ohio (Woronecki et al. 1981). However in Idaho sweet cornfields the presence of high earworn numbers may have served to reduce blackbird damage (Stone and Mott 1973) and in Virginia starlings fed only on earworms and fall armyworms (Spodoptera frugiperda) without damaging the ears (Stewart 1973).

GRAIN SORGHUM (MILO MAIZE)

Grain sorghum was planted on 16 million acres (4.4% of U.S. crop acreage) and ranked fourth of the 19 major crops in 1982 (Statistical Reporting Service 1983a). Bird damage to ripening grain sorghum in the U.S., caused chiefly by the Red-winged Blackbird, House Sparrow, and Brown-headed Cowbird, was estimated at $5.8 million in 1974 (Knittle and Guarino 1976). The Common Crow, the Boat-tailed Grackle, the Great-tailed Grackle, and the White-winged Dove also damage ripening grain sorghum. Bird damage is probably increasing as the range of grain sorghum is being extended (23 states grew more than 10,000 acres in 1982) and cultivars with higher protein content are gaining favor, especially with birds (L. Gourley 1974, pers. comm.). Damage to sprouting grain sorghum, probably largely caused by the Common Grackle, is minor compared to that occurring in the ripening crop. Bird damage to sprouting grain sorghum has been reported in 4 of 12 agricultural districts in Texas (Miears et al. 1964).

Bird damage to ripening grain sorghum is readily identifiable. Most species begin feeding on the uppermost kernels of the head leaving the empty glumes attached (Fig. 15). Damage becomes progressively greater as lower kernels are removed. Early removal of kernels from glumes is often followed by fungal invasion and these empty glumes quickly blacken.

Like corn, the amount of damage per day that an individual blackbird can cause is greater in the dough stage than when mature. Red-wings can consume about 1/4 to 1/2 ounce of mature sorghum daily, or about 10-15% of their body weight. In the early dough stage, which seems to be preferred by female red-wings and their young, the damage they are capable of causing is several times this amount. At this stage, red-wings often feed on the embryos (seed germs) only and drop the remainder of the kernel, leaving the soil littered with partially eaten seeds. A considerable portion of very early damage is compensated by the plant, if damage does not exceed 25%. In Mississippi, there was little loss of yield until >10% of the seeds at an early growth stage had been removed, as undamaged kernels increased in weight to compensate (Anonymous 1959).

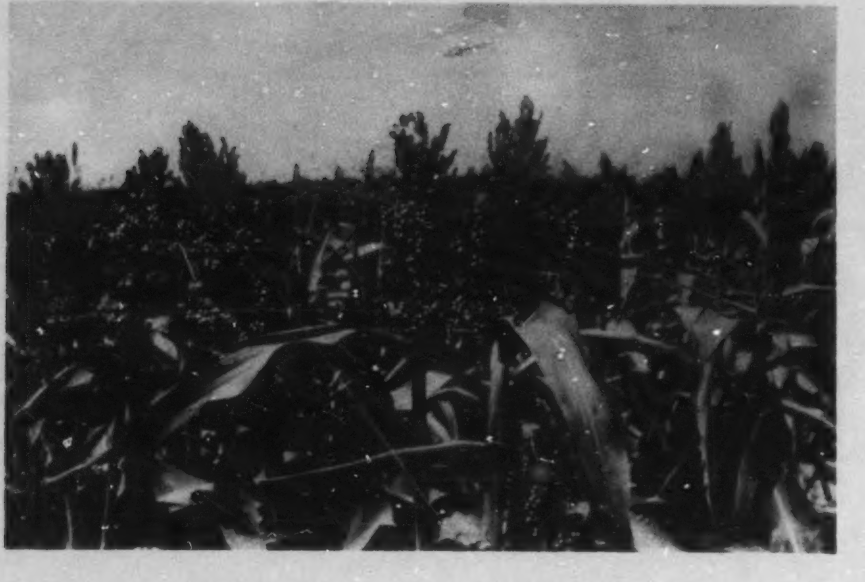


Fig. 15. Blackbird have removed many of the kernels from these heads of grain sorghum. Most species of birds begin feeding on the uppermost kernels, leaving the empty glumes. (Photo by John W. DeGrazio)

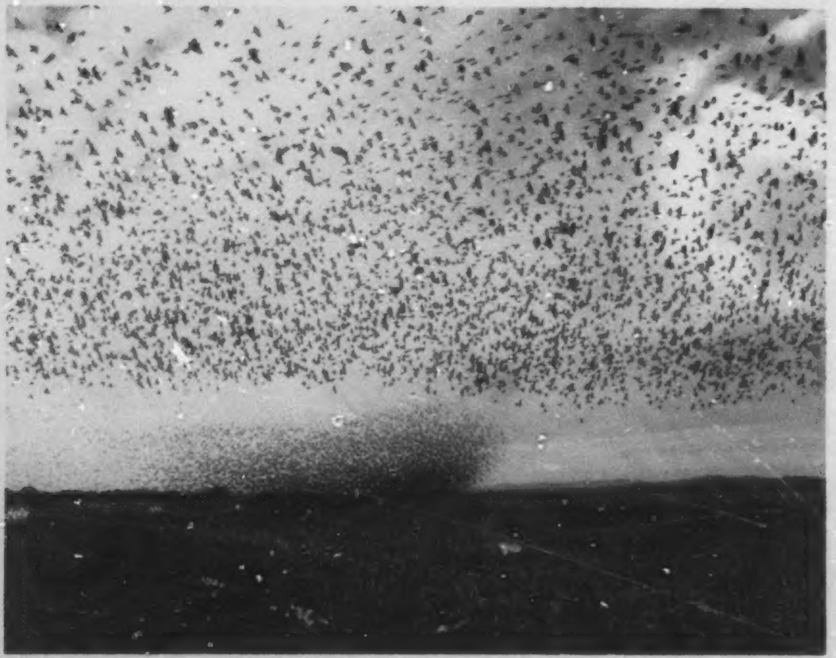


Fig. 16. Early harvest of mature grain sorghum can prevent scenes such as this one of thousands of blackbirds feeding in a harvestable field. (Photo by Gary Zahm)

## Protection of Grain Sorghum

The cultural practice most likely to prevent bird damage to mature seeds is to harvest them as soon as practical (Fig. 16). Dryers are especially recommended. Bird resistant varieties have found more favor with grain sorghum growers than growers of other crops, but most of these varieties, known as brown sorghums, contain enough tannins at harvest to reduce their palatability, digestability, and nutritional quality to livestock. However, there are some varieties which are resistant to birds in the early stages of kernel development but have been accepted well and have good nutritional qualities for livestock when harvested. In the latter varieties, apparently the tannins became too large to effectively bind with animal proteins (Bullard 1979).

Much of the discussion of mechanical means for protecting ripening corn is appropriate for grain sorghum also. Patrol of ripening grain sorghum fields is more productive than in cornfields, because feeding birds are seldom obscured by crop foliage. Shooting with a .22 caliber rifle from the field border is the most cost-efficient mechanical means. Patrolling is largely ineffective for house sparrows causing damage. Large numbers of sparrows can be taken in small decoy traps (Royall 1969) and then destroyed. The method may be effective in fields near isolated farm buildings. However, traps did not provide effective protection from sparrow damage when fields were located near towns and cities where a reservoir of newly hatched young regularly appeared to replace trapped birds (Royall 1969).

Chemical means for protecting ripening grain sorghum appear to hold the most promise for eventually relieving the severest damage to this crop. Repellent sprays and chemical frightening agents both have the potential to satisfactorily reduce severe damage.

A repellent spray has been used experimentally to protect ripening grain sorghum with excellent results. In Oklahoma, red-winged blackbirds consumed 11 times as much sorghum (39.7 vs 3.5%) in untreated fields as fields treated with 2 lb of aerially applied methiocarb (Mott et al. 1974). In South Dakota, blackbirds consumed 88% of the sorghum in untreated fields, but only 8% of the sorghum in fields treated with 3 lb of aerially applied methiocarb (Mott and Lewis 1976). Apparently grain sorghum can be protected with lower levels of methiocarb than other grains, because the seed is borne in open glumes, whereas most other seed grains such as rice and wheat are enclosed by glumes.

Methiocarb is repellent to most species of birds and should offer some protection to sorghum under all circumstances. In cage tests, it readily repelled house sparrows (Besser and Elias 1978) and has provided protection to ripening grain sorghum against several species of weaver birds in Africa (Bruggers et al. 1981) and doves in South America (Calvi et al. 1977). Unfortunately for growers, methiocarb is not yet federally registered for use in grain sorghum.

Chemical frightening agents, such as 4-AP, should be more effective in protecting ripening grain sorghum from blackbirds than they are for protecting corn, because affected and displaying birds should be less shielded by foliage and therefore more visible to other members of the flock. Again, unfortunately for growers, 4-AP has not been adequately tested for protecting ripening grain sorghum from blackbirds. Therefore, it is not registered nor available to growers at present.

The use of baits is much less expensive than the use of sprays. Per acre treatment costs of these two methods of chemical protection are estimated at \$15-\$30 for methiocarb sprays and about \$1.40-\$1.80 for 4-AP baits.

The principal reason that neither methiocarb nor 4-AP is available to growers is that the amount of grain sorghum acreage that could be economically protected with either of these agents is largely unknown. From the viewpoint of the products manufacturers it is unknown whether development costs could be repaid by sales (Fig. 17). If growers strongly desire to have either of these chemical agents made available, it appears that it is up to them to provide objective information on the extent of their losses either through their own surveys or through sponsored surveys. The procedures outlined under "Identification of the Amount of Losses" are applicable to losses in ripening grain sorghum. A simple objective procedure would be to harvest bird damaged acres separately from undamaged acres and report the difference in yields of the two. As stated previously, the Wildlife Research Center of the U.S. Fish and Wildlife Service at Denver, Colorado, will serve as a clearing house for objective crop damage information.

## GRAINS--NON-ROW CROPS

Ripening grain, in fields that were drilled or sown,is more difficult to protect from birds than grain grown in planted rows that can be cultivated. This is because of inaccessibility of areas within fields and lack of large between-row spaces for baiting.

### RICE

Rice was planted on 3.3 million acres (0.9% of cropland) and ranked ninth among U.S. agricultural crops in 1982 (U.S.D.A. 1983a). Birds heavily damage both sprouting and ripening rice. Bird damage to sprouting rice in Arkansas was estimated at \$336,000, or \$0.59 per acre, in 1968 (Pierce 1970). Both Louisiana and Texas probably have bird problems in sprouting rice equal to or greater than Arkansas. Based on the Arkansas estimate, an extrapolated estimate of nationwide losses in sprouting rice for the period 1973-82 is \$3.7 million annually (Appendix A).

Fig. 17. Chemical development costs, which include studies to determine the translocation of chemical agents in crops such as this one, are extremely high and it is unknown whether such costs could be repaid by product sales to protect grain sorghum from birds. (Photo by Donald J. Cunningham)

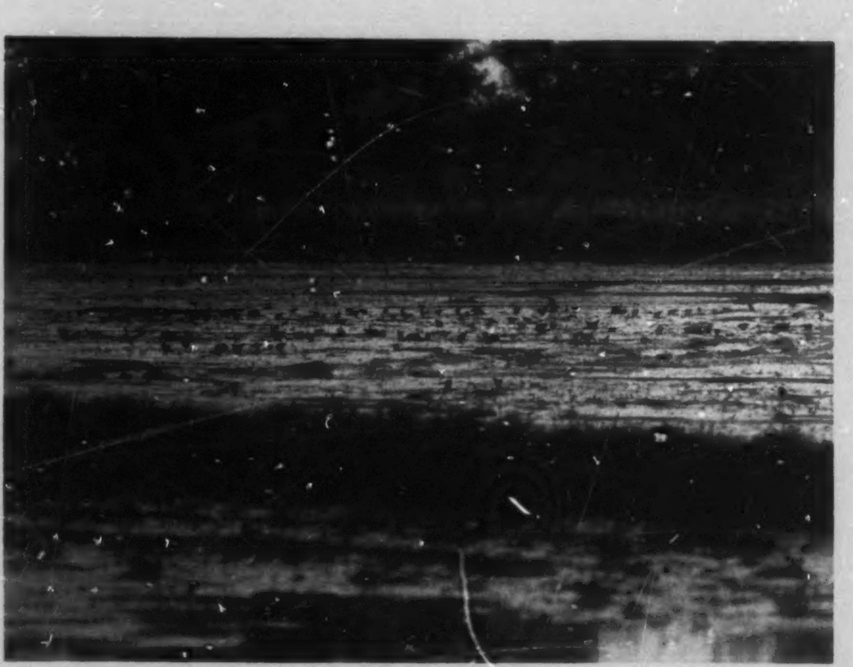


Fig. 18. A small number of red-winged blackbirds feeding in a sprouting ricefield, such as this one in Louisiana, can greatly reduce yields on several acres of rice. (Photo by Paul W. Lefebvre)

Losses of ripening rice in Arkansas were estimated at 1.5 million, or $2.62 per acre, in 1968 (Pierce 1970). Losses of ripening rice in California were estimated at about $75,000, or about $0.15 per acre, (DeHaven 1971). Based on these estimates, an extrapolated estimate of nationwide losses to birds in ripening rice for the period 1973-82 is $7.6 million annually (Appendix A). The combined national loss in rice for the 1973-82 period is estimated at $11.3 million annually.

Severe damage to blackbirds is sometimes incurrred by growers in south Texas in rattooned (second crop) rice. In a questionnaire survey, rice and grain sorghum growers in Calhoun County reported losses to birds totaling $421,000 in 1974 (G. Heideman, pers. comm., 1980).

Sprouting Rice

Damage to sprouting rice is caused chiefly by the Red-winged Blackbird and to a lesser extent by species of ducks, including the Blue-winged Teal, the Mottled Duck, and occasionally the Fulvous Whistling Duck.

Damage to sprouting rice by blackbirds can usually be recognized by the hulls left where the bird removed the seed kernel from the sprout and from the discarded sprout nearby. Duck damage to rice seeded in flooded paddies is more difficult to identify, because they also consume the seed coat. If the stand is very poor in the last places drained in a field, damage by ducks is likely.

The amount of damage an individual bird can cause in a sprouting ricefield is surprising. In Texas, few seedlings survived where an average of only 10-15 red-wings per acre were observed on experimental fields of rice sown in flooded paddies (Besser and Eastin 1979). An average of only 30 birds per acre were observed on an experimental plot of drilled rice that was completely destroyed (Besser 1973) (Fig. 18). Although some of the birds observed feeding on successive observations were different ones in both instances, it illustrates the small number of red-wings required to do considerable damage in sprouting rice. An individual duck is capable of inflicting greater damage than a blackbird, because of its larger size. Fulvous Whistling Ducks in Louisiana consumed about 2 ounces of sprouting rice per day (Imler et al. 1944). In Uruguay, the plant population on a 17-acre rice planting was reduced to 11,000 per acre after about 150 ducks, principally the White-faced Whistling Duck, fed for a 3-week period; about 9 ducks apparently were able to destroy an acre of rice (Calvi et al. 1977). About 373,000 seedlings per acre survived on an adjacent methiocarb-treated paddy.

## Protection of Sprouting Rice

Early seeding of rice invites bird damage. The grower can usually determine whether migrant blackbirds have departed and the local breeding birds have scattered over the area to nest. Seeding after March 15 in Louisiana and Texas, and after April 15 in Arkansas and Mississippi, will usually avoid attracting large flocks of migrants (Meanley 1971). In Arkansas, long-grain varieties do not have to be seeded before April 15 or short-grain varieties before May 1.

Bird damage to rice seeded in flooded paddies is often more severe than that drilled and then flooded. Drilling is recommended over seeding, if the land and the weather lend themselves to drilling.

The use of exploders, shell-crackers, and the .22 caliber rifle have been reported to be effective for frightening waterfowl from sprouting ricefields. However, shooting to frighten blackbirds from sprouting rice is likely to be less effective than ripening rice, for because much of the damage is caused by breeding birds that are not likely to abandon breeding territories.

Like in corn, the best method to reduce severe damage to sprouting rice is to treat the rice seed with a chemical repellent before seeding. In Texas, eight times as many rice seedlings survived on plots where seeds were treated with 8 ounces of methiocarb per hundredweight than on untreated plots where blackbirds were feeding (Besser 1973) (Fig. 19). In Louisiana, 30 times as many seedlings were damaged by blackbirds on untreated plots than on plots where seeds were treated with 4 ounces of methiocarb per hundredweight (Holler et al. 1982) and 14 times as many seedlings were damaged by blackbirds on untreated plots than on plots where seeds were treated with only 2 ounces of methiocarb (Mesurol® 75ST) per hundredweight (N. R. Holler, pers. comm.). Tests have not been conducted in the U.S. to determine the protection that methiocarb will afford sprouting rice against ducks, but in Uruguay, where ducks were feeding on sprouting rice, 33 times as many seedlings were found on the 7 acres of a field where seeds were treated with 5 ounces of methiocarb than on the untreated 17 acres (Calvi et al. 1977). The ducks causing damage were whistling ducks, teal, and pochards.

Methiocarb is presently available to growers as Mesurol® 75ST only in Louisiana and Arkansas under emergency use permits. Hopefully, it will be federally registered for use in all rice-growing states soon. Cost of protection is about $4 per acre. Growers, who have traditionally seeded at heavier than recommended rates to compensate somewhat for bird damage, should be able to recover some of their treatment costs with lower seeding rates.

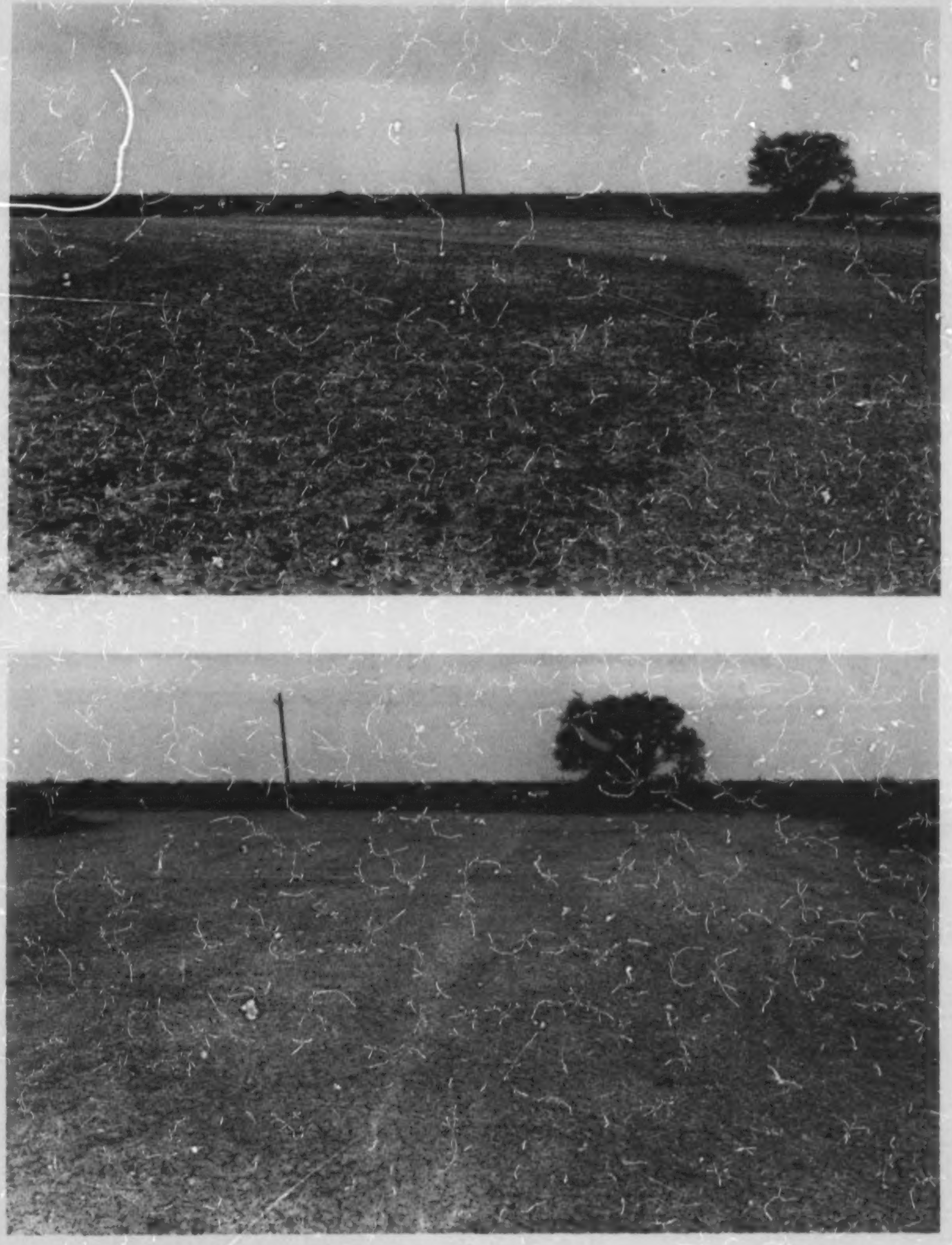


Fig. 19. Difference in the appearance of fields seeded with untreated rice (top) and methiocarb-treated rice (bottom). Blackbirds have "harrowed" the untreated field by overturning clods to obtain sprouting seed, whereas the treated field is largely undisturbed. Treated fields produced 8 times as many seedlings as untreated fields. (Photo by the author)

An alternative to treating all seed might be to overfly about 10 lb of methiocarb treated seed on acreages where damage is occurring (Besser and Eastin 1979). In a single Texas field where this was tried, an estimated 1,088,000 seedlings per acre grew on a treated field that had previously been destroyed by blackbirds and ducks when untreated; an estimated 1,150,000 seedlings (5.6% more than in exposed areas) were present within exclosures in this field. This method could cut chemical costs to about $1 per acre protected and reduce any adverse environmental effects of the chemical proportionately.

### Ripening Rice

Damage to ripening rice is most often caused by blackbirds. The Red-winged Blackbird and the Brown-headed Cowbird are the species chiefly responsible in the Southern Rice Belt; the Common Grackle and the Great-tailed Grackle are also involved (Meanley 1971). The Tri-colored blackbird often outnumbers the red-wing in California and the Brewer's Blackbird and the Yellow-headed Blackbird also damage rice in that state (Fig. 20). Some damage is also caused by the Dickcissel, the Bobolink, and ducks in the Gulf Coast Rice Belt. Bobolinks sometimes severely damage ripening rice in Florida also (P. Lefebvre, pers. comm., 1983). Members of the rail family (Railidae) also graze rice plants or use them in construction of nests. The American Coot, the Common Moorhen (Gallinule), and Purple Gallinule damage rice plants.

Blackbird damage to ripening rice in the milk stage can be identified by the dried milky particles scattered on the intact glumes; this is caused by the birds piercing and squeezing out the starchy contents. In later stages of maturity the kernel is missing and the hulls (glumes) are deposited on the ground (Fig. 21). Severely damaged panicles tend to remain upright, whereas panicles laden with kernels droop. However, at harvest, it is difficult to differentiate with any degree of accuracy between naturally blank hulls and those that had been crushed by birds while in the milk stage (Neff and Meanley 1957).

The amount of mature rice that three species of blackbirds and male mallards are able to consume daily has been determined. Caged red-wings, cowbirds, and grackles consumed about 1/2 ounce (0.43, 0.49, and 0.56 oz, respectively) of rice daily (Meanley 1971). Rates were somewhat higher (0.80 oz daily) for caged tri-colored blackbirds feeding on dough stage rice and intermediate (0.67 oz daily) for red-wings and tri-colors feeding on late dough-stage rice (DeHaven et al. 1971). Adult male mallards consumed 2.5 oz of mature rice daily (Jordan 1953).

Loss assessment in ripening ricefields is difficult because of the inaccessibility of sample plots and the problem of differentiating blank hulls from those crushed by birds in the milk stage. In Arkansas, random 1 square foot plots were assessed for numbers of kernels broken and removed by birds (leaving only empty nodes and flattened hulls); by determining the average

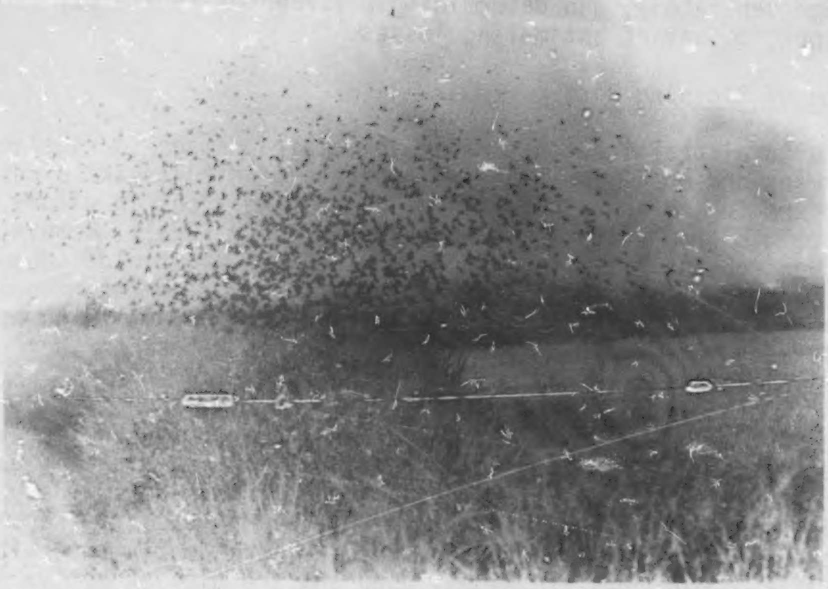


Fig. 20. A mixed blackbird flock attacking a field of rice in California. Tri-colored blackbirds often outnumber red-winged blackbirds in such flocks in California. (Photo by Frederick T. Crase)

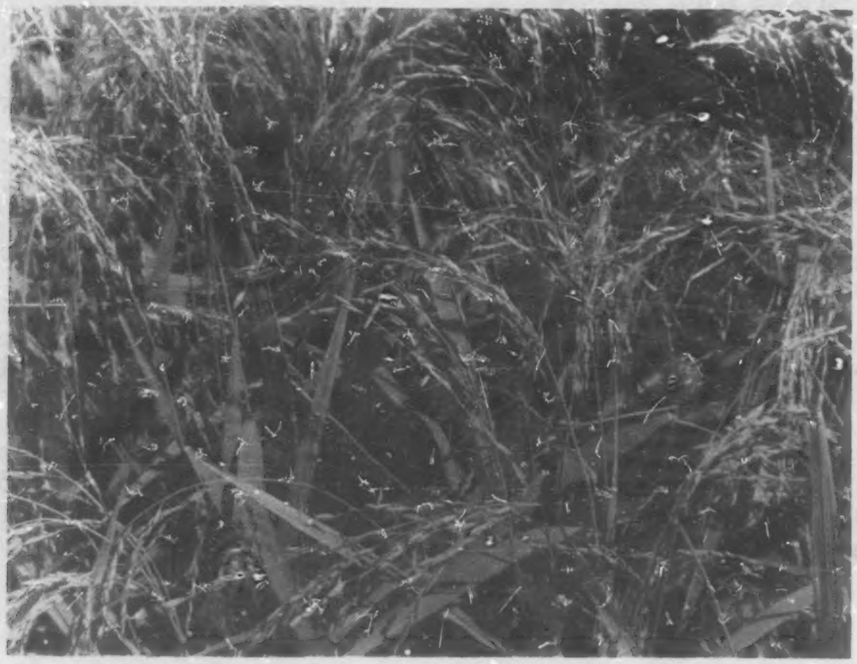


Fig. 21. The number of broken stems and crushed and missing kernels signify that blackbirds have fed heavily in this Arkansas ricefield. (Photo by Paul W. Lefebvre)

weight of filled kernels, the maximum loss was calculated and by deducting the number of flattened hulls, the minimum loss was determined (Neff and Meanley 1957). As suggested for grain sorghum, combining acreages with and without bird damage separately, and determining differences in yields, is a simpler, but less precise way of estimating losses.

## Protection of Ripening Rice

Two cultural practices that reduce blackbird damage to ricefields are clean farming and modifying adjacent habitats. In Arkansas, birds used brushy field borders for cover when harassed, as loafing areas in midday, and as assembly points from which to attack rice (Meanley 1971). Removal of this brushy cover substantially reduced damage to some ricefields (Meanley 1971). Draining ripening fields as early as practical was also recommended, because red-wings apparently preferred to roost over water and large numbers of birds roosted in many rice fields. Harvesting the crop before northern migrant birds arrive also reduces damage.

The use of scaring devices to drive birds away from ricefields is often the only effective, practical means of combating blackbird attack (Meanley 1971). The .22 caliber rimfire rifle is the best and perhaps most widely used device in ricefields. A shooting stand, 15 to 20 feet in height is recommended. Shellcrackers are effective but protection is more costly than with the .22 caliber rifle. Exploders are widely used and are also effective if shifted often to cover those areas where bird numbers are increasing. Air patrol of ricefields is only effective if assisted by ground patrol (Meanley 1971).

Shellcrackers and exploders are effective for reducing duck damage in daylight. Revolving lights are the only mechanical means of effectively reducing damage by night-feeding ducks. Large decoy traps proved useful in reducing damage by cowbirds to ripening rice in one Arkansas study. About 40,000 blackbirds, or 39 birds per trap per day, were taken and destroyed in 20 large decoy traps (Caslick *et al.* 1963) (Fig. 22). However, decoy traps were less effective in capturing red-wings. Decoy traps readily captured tri-colored and yellow-headed blackbirds in California, but also failed to capture red-wings (DeHaven 1971). In addition to seldom capturing red-wings, the chief species responsible for damage in many areas, construction and maintenance of large traps is time consuming.

Chemical means for protecting ripening rice from birds holds less promise than for most other grains, because rice kernels are enclosed in glumes and greater amounts of repellent sprays are needed to protect rice than grain sorghum. In California, a 5 lb/acre application of methiocarb reduced blackbird damage by only 38% (Crase 1974) (Fig. 23). Baits containing chemical frightening agents or toxicants can not be effectively applied in ricefields in the milk and dough stages of maturity. Baits may be of some use in rattooned crops, where baiting lanes would cause less loss because of lower yields, and blackbird losses are sometimes much higher.

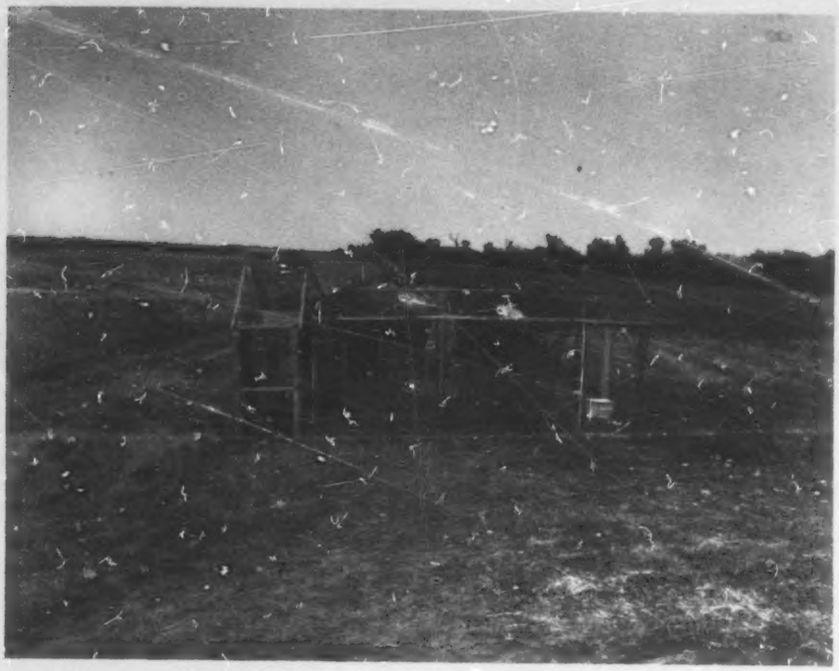


Fig. 22. About 40,000 blackbirds were taken in large decoy traps, such as this one, to protect ripening rice from damage in Arkansas in 1963. (Photo by John W. DeGrazio)

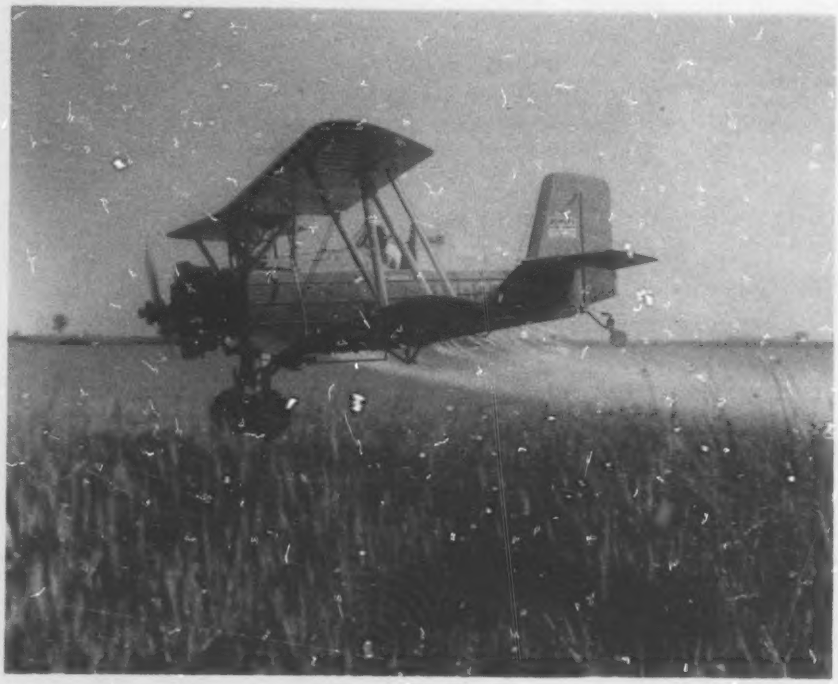


Fig. 23. Repellent sprays to protect ripening rice, such as this one being applied in a ricefield in California, hold less promise for this crop than for grain sorghums, because rice kernels are covered by glumes and grain sorghum kernels are not. (Photo by Frederick T. Crase)

## Wild Rice

Wild rice was grown in about 20,000 acres of commercial paddies in Minnesota in 1978 (Office of Federal Register 1978). The Minnesota Department of Agriculture estimated losses to blackbirds would have been between $1.5 to $3.0 million in 1978, had damage not been controlled (Office of Federal Register 1978); wild rice sold for $4.50 per pound that year (H. Sabol, pers. comm., 1978). These figures indicate that blackbirds consumed more than 20% of the 1.5 million pound crop processed in 1977 (Moulton 1979). The Red-winged Blackbird is the chief species that damages wild rice.

Assessment of losses to birds in wild rice is even more difficult than in domestic rice, because the first seeds produced tend to shatter and loss is sometimes attributable to both bird consumption and feeding activity. Blackbird-exclosed 4 $ft^2$ plots were used to evaluate the effect of a chemical treatment in Minnesota (Moulton 1979). Machine harvesting of damaged and undamaged areas of commercial paddies separately might also be tried for appraising damage.

From the magnitude of the damage sustained ("well over 50% in some fields"; Office of Federal Register 1978), many methods of frightening birds from paddies (by rifle and shell-cracker patrol, with propane exploders, and by broadcasting distress and alarm calls) should be cost-effective. However, only experiments with repellent sprays of methiocarb for protection of wild rice have been reported. In 1976 and 1977 studies, residue levels of methiocarb on aerially sprayed grain, bird numbers, and protection obtained were variable. A 2 lb/acre methiocarb treatment reduced damage by 76% in 1976 when blackbird numbers were high and rainfall was low, but less protection was provided in 1977 when blackbird numbers were lower and it rained frequently (Moulton 1979). It appears that methiocarb may not be commercially available for this use in the near future.

## WHEAT

Wheat was planted on 87.3 million acres (24.1% of cropland), the greatest acreage of any U.S. crop in 1982 (Statistical Reporting Service 1983a). Bird damage to sprouting wheat is locally serious only in the mid-South (Kentucky and Tennessee) where winter wheat is grown. Bird damage to ripening wheat is serious only in the Dakotas, where wheat is often grown adjacent to marshes used by blackbirds for breeding, molting, and roosting. Ripening durum wheat is more heavily attacked than red wheat. The most serious damage to wheat is caused by waterfowl when wheat is swathed for long periods during wet weather.

Damage to sprouting wheat is caused almost entirely by the European Starling; occasionally damage by the Red-winged Blackbird and the Common Grackle is reported. Damage to standing ripening wheat is largely caused by the Yellow-headed Blackbird and the Red-winged Blackbird. Damage to swathed wheat is chiefly caused by the Mallard, although other ducks, geese and the Yellow-headed Blackbird are sometimes involved (Knittle and Porter, In prep.).

In an objective survey in 1977, losses of sprouting wheat to birds in Kentucky and Tennessee were estimated at $0.5 million (Dolbeer et al. 1978/1979). In 1968, Arkansas growers estimated blackbird damage to seeded wheat at $0.35 per acre (Pierce 1970). Monetary losses to standing ripening wheat have never been estimated. Losses of swathed wheat to mallards and other ducks in North Dakota, South Dakota, and Minnesota were estimated at $0.6 million in 1981 (W. K. Pfeifer and R. V. Hansen, pers. comm.) (Fig. 24). However, in 1974, a U. S. Department of Agriculture questionnaire survey indicated that land owners in 3 North Dakota counties estimated losses to ducks and geese at $2.4 million, or $900 per farm (Miller 1976). Apparently 1974 was a year of exceptionally high waterfowl damage. Caged male mallards consumed an average of 2.6 ounces of mature wheat daily, blue-winged teal 1.0 ounces, and Canada geese 6.6 ounces in an Illinois study (Jordan 1953).

Estimated losses for all wheat total $1.2 million, but are probably much higher since estimates are available from only the states receiving the most serious damage and no estimates are available for blackbird damage to ripening wheat. The author has observed ripening durum wheat fields near Bottineau, North Dakota, where red-winged blackbirds had removed more than half of the kernels in about 5 acres. North Dakota growers frequently complain that they obtain little or no yield from areas of wheat fields within 50 yards and sometimes farther from marshes where blackbirds breed.

Starling damage to sprouting wheat can be identified by the small (1/4-inch) round holes left when a sprouting seed is removed from the soil; often the sprout with the seed removed is found adjacent to the hole. Blackbird damage to ripening wheat can be identified by the kernels (ears) missing from nodes and by the hulls (often with awns or beards attached) deposited on the soil surface; blackbird damage to swathed wheat is similar but most discarded hulls are located beneath the swath. Duck damage to swathed wheat is identifiable by missing kernels from entire areas of heads, and by compression of the swath into the stubble. It is estimated that ducks cause nearly three times as much loss by trampling swaths during wet weather as is lost in grain they consume.

Assessment of losses from sprout pulling is best determined from 1 to 3 square foot sampling plots randomly located throughout the field; 10 plots per field were used in the Kentucky and Tennessee surveys (Dolbeer et al. 1978/1979). Growers can most easily determine losses in ripening and swathed wheat by harvesting bird damaged areas and undamaged areas separately.

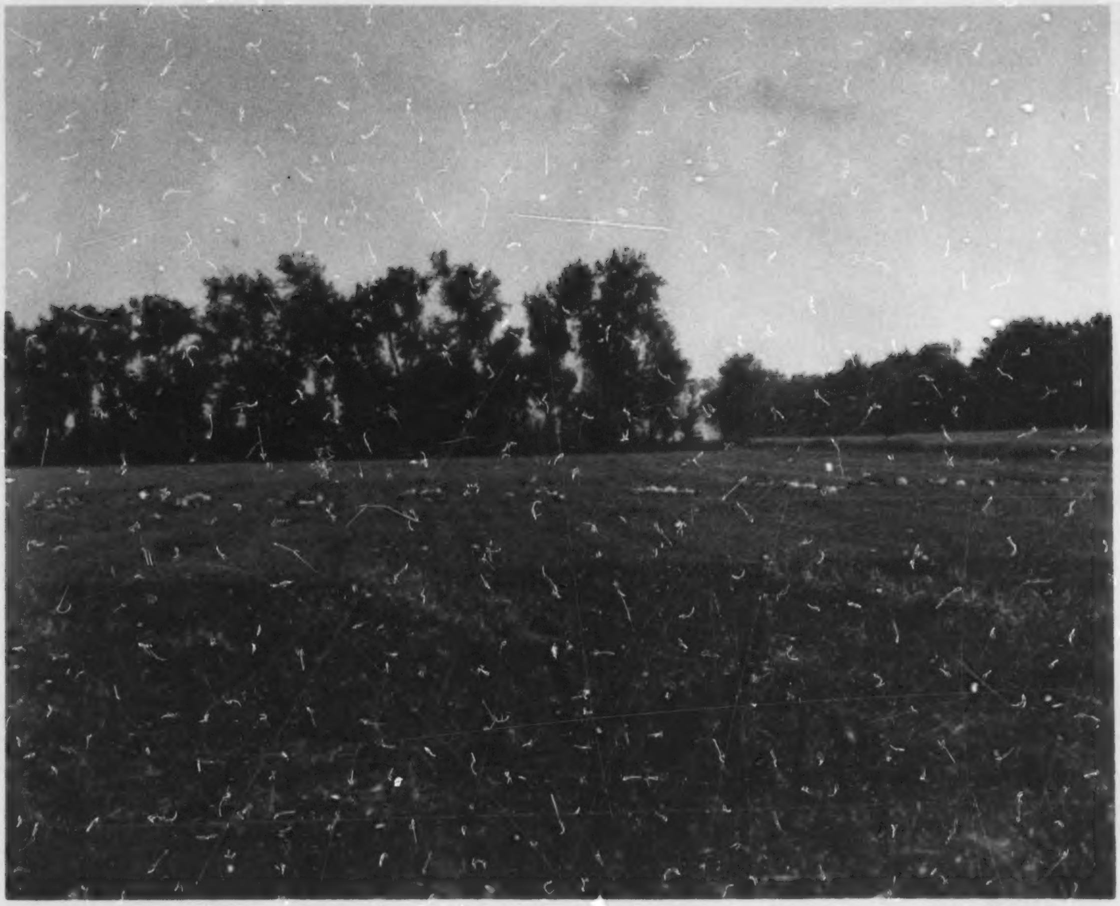


Fig. 24. Ducks and geese feeding on wheat swaths in South Dakota. (Photo by the author).

## Protection of Sprouting Wheat

Seeding winter wheat before northern migrants arrive is the cultural practice most likely to relieve damage by starlings. Fields in Kentucky and Tennessee that were planted in October received substantially less damage than those planted later (Dolbeer et al. 1978/1979). Planting depths of 1-1/2 to 2 inches may be worthy of trials in high starling damage areas.

Exploders are probably the most cost-effective means of frightening starlings from sprouting wheat fields under regular attack. The .22 caliber rifle and shellcrackers are effective if the grower has opportunities to visit the field regularly or if damage occurs for brief periods. Amplified distress calls and electronic noise are especially effective for starlings, but to my knowledge they have not been tried for protecting sprouting wheat, perhaps because of high initial cost.

Although the chemical repellent, methiocarb, has been very effective for protecting other sprouting grains, field trials for protecting sprouting wheat from starlings have not been conducted with present seed treatment formulations. Since methiocarb is only about 1/3 as repellent to starlings as red-winged blackbirds (Schafer et al. 1983), three times the level found effective on sprouting rice may be necessary for satisfactory protection, or about 8 oz a.i./hundredweight. Again, need, cost-benefits, and market potential will dictate development of an effective chemical for this use.

## Protection of Ripening Wheat

Not seeding near marshes is a good but usually impractical cultural practice for reducing blackbird damage to ripening wheat. It is doubtful that mechanical means of protection would be cost effective in most damage situations. However, it has been reported that simple scaring devices, termed "flashers", have been successful in reducing blackbird damage to crops, if employed at one "flasher" per 10 to 15 acres (Canadian Wildlife Service 1982). A "flasher" is constructed by slitting the sides of discarded, large, plastic bottles to form fins, and mounting the open end of the bottle on a dowel atop a post, so that the wind will catch the fins and impart motion. Painting the fins with fluorescent paint may improve effectiveness.

Spraying strips of wheat adjacent to marshes with repellent sprays may be cost effective where losses are severe. However, the small acreages damaged, the need to apply the chemical aerially, and the high application rates probably necessary (since the kernel is covered by glumes) all make the development of chemical repellents for protecting ripening wheat unattractive. Initial attempts to determine the amount of methiocarb spray needed were inconclusive because of insufficient bird pressure (Knittle et al. 1976).

## Protection of Swathed Wheat

A speedy and early harvest is the best cultural practice for minimizing bird losses to swathed wheat. Unfortunately, the weather in a state such as North Dakota often does not cooperate, or combining standing wheat without swathing would be more widely practiced. Elimination of weeds with herbicides permits greater acreages of standing heads to be combined. Seeding earlier maturing varieties, which permit earlier harvest, reduces the number of migrant birds present to attack swathed fields and may increase the growers' opportunity to combine standing heads. The stubble of early-harvested grains, such as rye, formerly acted as a buffer when foul weather impeded the harvest of later maturing grains (Miller 1976). However, fall plowing with increasingly larger machinery now enables farmers to quickly turn under there stubbles. Delaying plowing of early-harvested grains is a cultural practice that should reduce damage to swaths of later-harvested grains, particuarly when wet weather delays harvests.

Exploders are probably the most cost-effective of mechanical means of protection and are especially effective for ducks that are heavily hunted. Exploders can be operated without attendance for up to 3 weeks, if no mechanical problems occur. Initial cost for the better models is about $200, but their operating life is 5 or more years. An exploder may protect 40 or more acres from ducks. Scarecrows are also effective for ducks. Inexpensive scarecrows can be made by nailing a 2 foot-square sheet of black plastic on a 6-foot section of lath. A plastic garbage bag, attached by twine to a post at the two outer points of the open end, will catch the wind and flutter in a life-like manner (Canadian Wildlife Service 1982). Placing a scarecrow about every 100 yards on the best vantage points for feeding ducks often reduces damage. Shellcrackers are particularly effective for ducks and the .22 caliber rifle is also useful. For night feeding ducks, flashing, revolving lights are recommended and have protected up to 640 acres of crop (Zajanc 1958).

A chemical repellent spray, 2 lb methiocarb per acre, has been tried on swathed wheat, but large numbers of mallard and pintail ducks arrived so steadily that birds that may have been repelled by the treatment and left the area had little effect on new arrivals decoyed by those that had just begun feeding (Cunningham 1976). The previous year, apparent repellent effects had been noted when a small flock of 60 ducks fed on methiocarb-treated swaths (Cunningham and Knittle 1976).

Damage by ducks from trampling swaths in wet weather can probably be as cost effectively combated by leaving birds on a field once the damage has become serious. This offers relief from trampling to other fields in the area and allows ducks to consume the grain already largely ruined. It may be desirable for an association or the government to compensate the grower for the damage caused by game species. A North Dakota study showed the advantages of such "lure" fields in reducing duck damage in a given locality (Fairaizl 1982), but obtaining a sponsor to pay growers for losses incurred in such "lure" fields may be difficult (Knittle and Porter, in prep.).

Baiting or feeding ducks in congregating areas with grains from a previous crop also relieves losses to ducks from trampling damage (Knittle and Porter, in prep.). However, it is sometimes difficult to hold a large percentage of birds, especially migrants, on such sites.

Blackbird damage to swathed wheat is seldom serious enough to warrant control efforts. When warranted, exploders are probably most cost effective.

## BARLEY

Barley was planted on 9.6 million acres (2.6% of cropland) and ranked seventh in acreage among U.S. crops in 1982 (Statistical Reporting Service 1983a). Bird damage to sprouting barley is negligible and is serious to ripening and swathed barley only in the Dakotas.

Damage to ripening and swathed barley in the Dakotas is caused by the same species responsible for damage to ripening and swathed wheat. Monetary losses in barley are often included with wheat losses, so that no accurate loss information is available for barley alone. Identification of loss, field assessment procedures, and methods for alleviating losses are similar to those given for damage to ripening and swathed wheat.

## OATS

Oats was sown on 14.2 million acres (3.9% of cropland) and ranked fifth in acreage of U.S. crops in 1982 (Statistical Reporting Service 1983a). Because it is sown and ripens earlier than most grain crops, it is subject to widespread, but generally light, damage by birds.

Oats is a favored blackbird food. However, the northward spring migration of blackbirds is rapid and as soils are cool at this time, losses of oat sprouts to birds are often largely compensated by later germinating sprouts and the stooling of remaining plants. Arkansas growers in a 1968 survey, estimated blackbird damage to sprouting oats at only $.08 per acre (Pierce 1970). However, in Nevada, Arizona, and California, oats are often seeded in winter and blackbirds occasionally cause serious damage to sprouts. Exploders would probably be effective in reducing losses in these instances. Repellent seed treatments should be effective against blackbird damage to sprouting oats, but it is unlikely that chemicals will be registered for this use unless a small grain (group) registration can be obtained.

Oats generally ripen while blackbirds are still widely dispersed on breeding territories, hence bird damage is seldom serious enough to warrant control efforts. Noteworthy damage to ripening oats occurs near a few large colonies of nesting tri-colored blackbirds in California. Again, exploders could probably reduce much of this loss.

## RYE

Rye was seeded on 2.6 million acres (0.7% of cropland) and ranked tenth in acreage of U.S. crops in 1982 (Statistical Reporting Services 1983a). Most rye is seeded for forage and as a cover crop, and only 0.7 million acres (27%) were harvested for grain. Maturing rye does not appear to be a preferred blackbird food (J. W. De Grazio, pers. comm.), but they do damage sprouting rye. In 1968, Arkansas growers estimated blackbird damage to sprouting rye was $0.33 per acre (Pierce 1970). Exploders should reduce losses of sprouting rye to blackbirds. Repellent seed treatments should be effective for blackbird damage to sprouting rye, but may not be cost-effective and are unlikely to be registered for this use without a small grain (group) registration.

## OILSEEDS

### SUNFLOWER

Sunflower was planted on 5.0 million acres (1.4% of cropland) and ranked eighth in acreage among U.S. crops in 1982 (Statistical Reporting Service 1983a). Most of this acreage is in the Dakotas and Minnesota, an area that has long been a banquet table for birds. Sunflower growers recently have added a large and peferred dish to this table. A similar dish, the wild sunflower, has been present for millenia, but not in such concentrated quantity as cultivated sunflower. Wild sunflower has been found in the diets of many species of birds in numerous food habit studies conducted since this area was first plowed. Since the advent of both effective herbicides and improved cultural practices, patches and scattered plants of wild sunflower are seen less commonly. Thus, cultivated sunflower may be replacing wild sunflower in the diet of many species of birds.

Information from objective surveys on losses of ripening sunflower to birds in North Dakota is available for 1972 and 1978, and for the major sunflower-producing states for 1979 and 1980. Acreages and losses to birds in North Dakota have increased on each survey, except in 1980. North Dakota losses were estimated at $300,000 on 0.4 million acres in 1972 (Henne et al. 1979), at $2.7 million on 1.9 million acres in 1978 (Henne et al. 1979), at $3.6 million on 3.4 million acres in 1979 (DeHaven 1982) and at $7.4 million on 2.2 million acres in 1980 (DeHaven 1982). Losses in North Dakota, South Dakota, and Minnesota totaled $5.0 million in 1979 and $8.7 million in 1980 (DeHaven 1982).

Blackbirds are the principal family of birds that damage ripening sunflower in the U.S. (Fig. 25). The Red-winged Blackbird probably damages more sunflower than all other species of blackbirds combined (Fig. 26). Other important species of blackbirds damaging sunflower are the Common Grackle and the Yellow-headed Blackbird. Many other species including the House Sparrow, House Finch, Pine Siskin, Common Goldfinch, Blue Jay, Brown Thrasher, and Common Crow take seed from standing heads, but none other than house sparrows and house finches cause noteworthy damage.

Damage to sunflower sometimes begins even before ray petals fall, and continues until harvest. The most severe damage often takes place within 2 weeks after ray petals begin to wither (Fig. 27). Sometimes within a week and occasionally within 3 days, red-wings discontinue attacking a field in favor of finding one where the outer whorl of seeds are just beginning to fill. Yellow-heads and grackles often feed in fields that have the seeds filled and grackles may actually prefer the more advanced stages of sunflower ripeness, as they do in corn.

The amount of damage an individual blackbird can cause in a sunflower field in a day is greater in the soft seed stage (green or yellowish-green bowls) than later. Caged male red-wings (more than half again as large as females) caused at-harvest losses of 1.4 ounces of seed daily when seeds were half-filled and 0.8 ounces daily when seeds were filled or nearly so (Besser 1979a). Bird damage can be differentiated from wind shattering by noting that seeds on the soil surface will be split and the kernel extracted if damage is caused by birds. Birds deposit many empty hulls in the bowl formed by the inverted head, but wind soon removes many of these. Many growers believe that blackbirds waste many seeds, but examination of seeds on the soil surface shows that nearly all have been split and the kernel removed. If feeding on heads occurs very early and is light, this feeding is sometimes obscured by the outer bracts of the heads slumping to cover the areas where seed has been removed. Although this feeding is sometimes missed while appraising damage, the plant largely compensates for this very early feeding by increased weight in undamaged seeds (Smith and Oldemeyer 1982a; Sedgwick et al. 1983b). On the other hand, assessments made at harvest time often underestimate losses, because damaged areas of the head have shrunk an average of about 30% at harvest (Besser et al. 1981; Smith and Oldemeyer, 1982b; Sedgwick et al. 1983a).

Objective assessment of losses can be made on random sample plots or by harvesting damaged and undamaged areas of the field separately. In random sampling fields, the appraiser should ensure that all portions of odd-shaped fields are included in the sample; odd-shaped fields in Minnesota had nearly four times as much damage as rectangular ones (Besser 1979b).

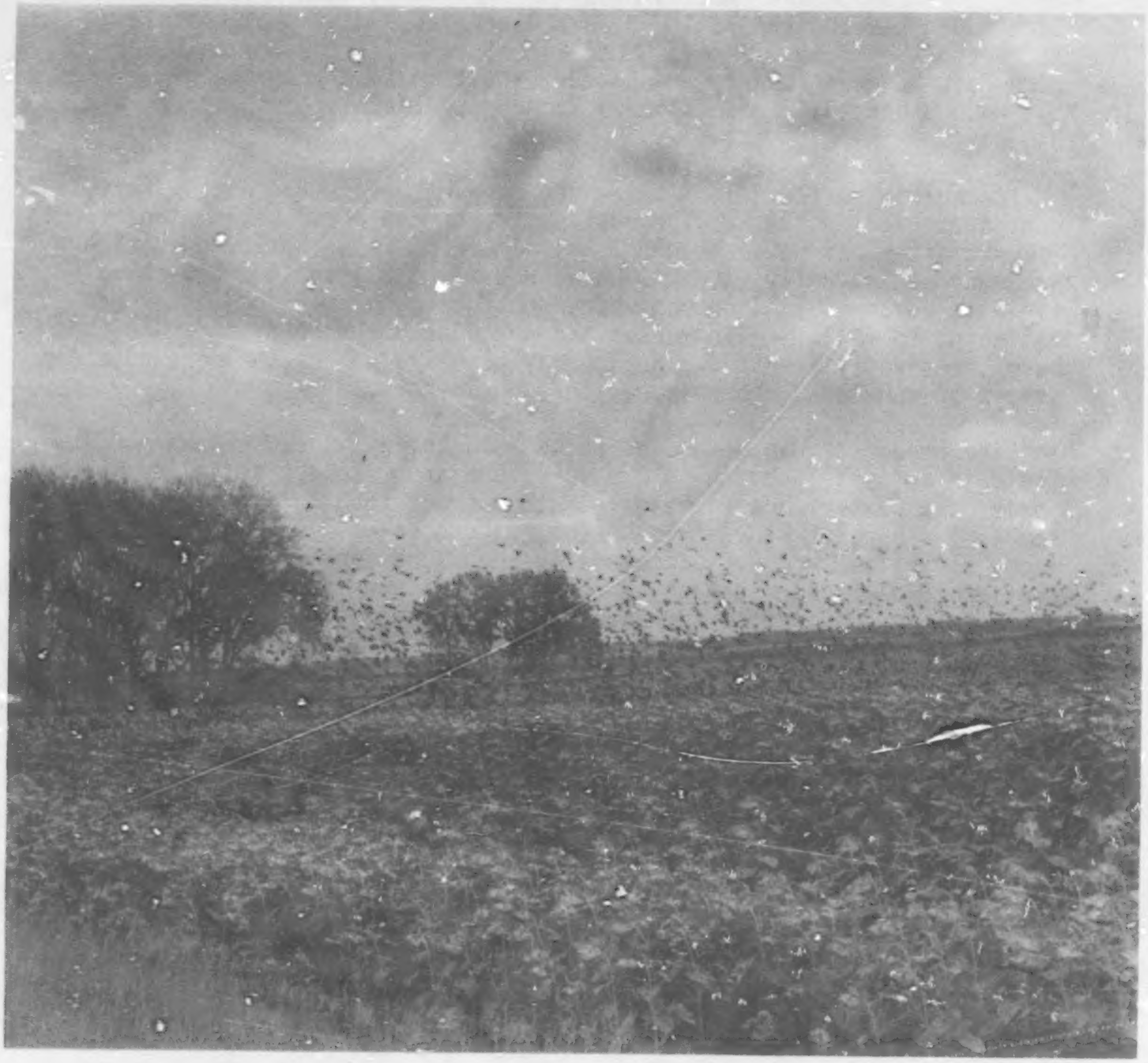


Fig. 25. Blackbirds, such as this flightline of red-winged blackbirds arriving to feed in a field of ripening sunflower in Steele County, North Dakota, are the principal family of birds that damage this crop in the U. S. (Photo by the author)

Fig. 26. Red-wings are the chief species of blackbirds that damage sunflower. (Photo by Paul W. Lefebvre)

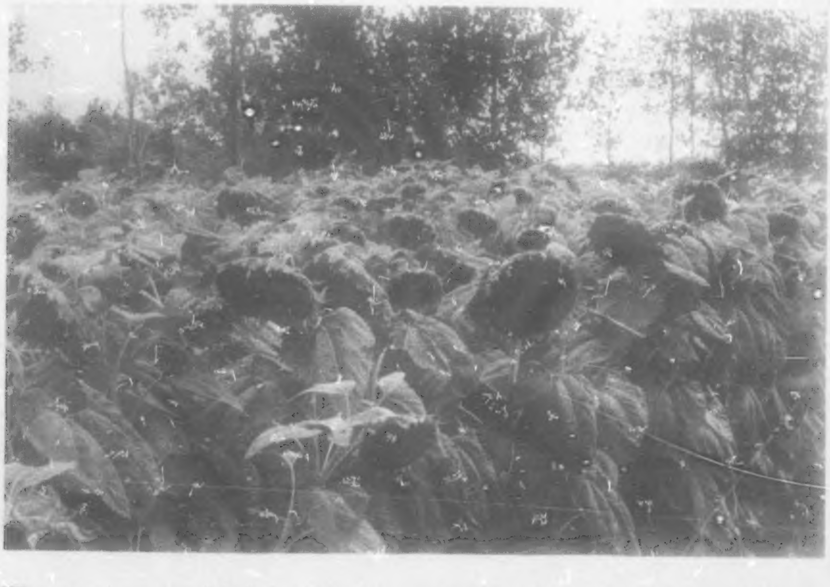


Fig. 27. The most severe bird damage to sunflower often takes place within two weeks after ray petals begin to wither. Sunflower in this field has already sustained about 30% damage and the florets atop the seeds have not as yet fallen. (Photo by the author)

## Protection of Sunflower

The amount of damage sustained by a ripening sunflower field is often directly related to its proximity to a marsh used by blackbirds for roosting. Fields should not be planted within 1/4 mile of small marshes or sloughs that consistently harbor 5,000 or more roosting or loafing blackbirds in late summer (Pfeifer 1975). Growers should avoid planting sunflower adjacent to shelterbelts, groves, or other woody areas regularly used by blackbirds for loafing cover. Within 100 yards of such cover a grower should substitute a crop that blackbirds do not harm, such as flax, sugar beets, potatoes, soybeans, or pinto beans. Hard red spring wheat also sustains much less damage than sunflower.

If farmers cannot select an alternate crop or a site to grow sunflower far enough from marshes and trees to provide a degree of bird protection, they should at least plant at a lower rate to produce very large heads that are less susceptible to bird damage. Farmers should plan their plantings with neighbors to assure uniform ripening of the crop in the community, so that a single or a few growers will not have the only fields within the feeding range of a large roost of birds. The cultural practice most likely to reduce bird loss is an early harvest. In some years, harvest can be accomplished before the peak of blackbird migration, if blackbird breeding seasons have been delayed. Use of dessicants and driers is especially recommended. Early maturing varieties sometimes also mature before the peak of blackbird migrations. Varieties that have long bracts, that invert at an early time, whose heads when inverted are most distant from the plant and its leaves, and whose seeds contain bird repellent substances or colors are subject to less damage (Fox _et al_. 1982). However, yields of these varieties have been less than non-resistant varieties, and none are yet available to growers.

Birds prefer certain varieties of cultivated sunflower. Surprisingly, the oilseed cultivars are preferred by most birds over confectionery varieties or even those cultivars specifically planted for the bird feed market. Apparently persons buying sunflower seed for feeding stations buy the large or striped seeds more for appearance than from knowledge of bird preference or nutritive needs. Losses in oilseed cultivars were 1.6 times greater than in non-oil seed varieties in North Dakota in 1972 (Besser and Besser 1979). Growers suffering high bird losses of oilseed sunflower might consider growing non-oil seed sunflower to lower losses.

The most underrated cultural practice for relieving bird damage is both effective and simple. A major portion of harvested cropland near blackbird roosts should not be plowed or tilled until most or all sunflower fields have been harvested. Delaying tillage of nearby cropland is practiced by many of the wiser farmers and is recommended to lessen damage to sunflower (Pfeifer 1975). Birds, especially blackbirds, consume great quantities of weed seeds and some insects from crop stubbles. The probable benefit of blackbirds reducing weeds and insect numbers while feeding in grain stubbles is not well established, but leaving grain stubbles near blackbird roosts reduces crop damage. It is pertinent that the August diet of red-winged blackbirds in a North Dakota sunflower-growing area consisted of 41% foxtail or pigeon grass (Setaria) and only 26% sunflower (Linz et al. 1982). Unfortunately, farmers living near marshes often are unwilling to delay fall tillage of part of their grain stubbles to accommodate farmers growing sunflower. In some areas, farmers with fields near marshland were forced to cease growing sunflower because of birds.

After harvesting sunflower, the stubble with its shattered seed should be left as alternate feeding areas until all sunflower in the area is harvested. Leaving sunflower stubbles as alternate feeding areas is especially important if all grain stubble in the area has been tilled. There may even be benefits in control of volunteer sunflower by birds if tilling of stubbles are delayed. As the sunflower belt has moved westward onto the Northern Great Plains in recent years, farmers in this region tend to till stubbles less in the fall, both for wind erosion control and moisture conservation. This practice leaves more alternate field-feeding sites for birds and contrasts with the regular use of fall plowing to avoid wet soils in the spring that is common farther east, especially in the Red River Valley of North Dakota and Minnesota.

Most farmers are aware of the value of frightening birds from sunflower fields by patrol with rifles and shotguns, or using exploders and pyrotechnics (Fig. 28). They also know this activity requires several hours each morning and evening, and occasionally all day. Since sunflower is vulnerable to birds for approximately 6 weeks--longer than any other crop grown in the U.S.--protection of sunflower fields by mechanical means is an especially formidable task and one likely to discourage the grower long before harvest. Nevertheless, persevering farmers can nearly fully protect their crop by patrol. Methods for using mechanical means to protect sunflower from blackbirds are nearly identical to those used in ripening field corn and sunflower growers are advised to check that section of this bulletin. A technique that reportedly has shown some effectiveness in sunflower is a plastic owl used in conjunction with a distress call of blackbirds broadcast over fields (Appendix G). Its effectiveness has not yet been objectively evaluated.

Chemical frightening methods are replacing mechanical frightening methods in some areas (Fig. 29). The discovery of chemicals that cause some species of birds to emit cries during distress-display flights led to a new method of protecting sunflower--the use of chemical frightening agents. The ability of 4-aminopyridine (4-AP) to protect sunflower was first investigated in North Dakota in 1967. Nine years later (August 1976) 4-AP was federally registered to protect sunflower from blackbirds as the product Avitrol$^R$ FC Corn Chops-99S (AFCC-99S).

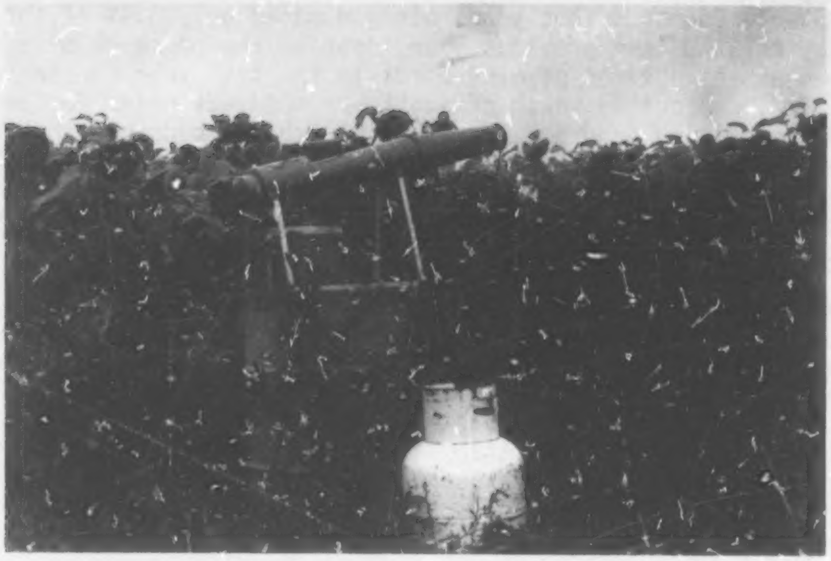


Fig. 28. This propane-powered exploder is mounted properly on a barrel and fires slightly above the crop. The adjacent heads were damaged before the exploder was installed. (Photo by the author)

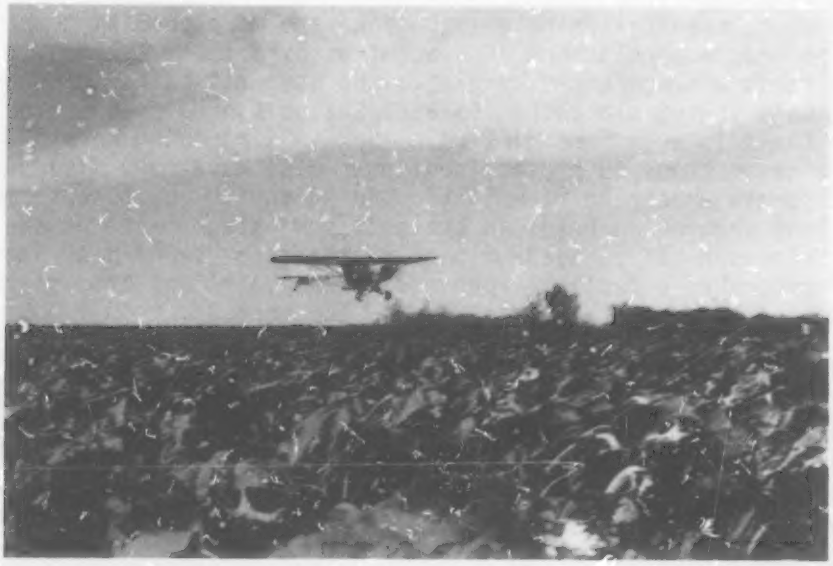


Fig. 29. A spray plane baiting a sunflower field in Traill County, North Dakota with a chemical frightening agent to protect it against blackbird attack. Only 1 lb. of the active ingredient, 4-aminopyridine, is used to treat 3,333 acres of sunflower field. (Photo by Donald R. Henne)

Most of the efficacy tests that led to registration of AFCC-99S were conducted in North Dakota. In 1973, AFCC-99S baits were broadcast at 1 lb/A from baiting lanes in all fields needing treatment in a 28 mi$^2$ area of Steele County. That year, birds damaged only 3.4% of the crop, compared with 23.6% the previous year, despite the presence of a peak population of seven times as many birds in the test year (Besser and Guarino 1977). About $9 worth of sunflower seed was saved for each $1 spent in the baiting program. In 1974, blackbirds consumed about 2.5 times as much sunflower seed in 12 untreated fields in Traill and Grand Forks counties as in 12 treated with AFCC-99S, and results were generally satisfactory in the 18,000 acres treated in Minnesota and the Dakotas that year (Besser and Cummings 1975).

Despite the effectiveness demonstrated in field tests, several problems have prevented growers from making the most effective use of AFCC-99S. These problems involve professional applicators, lack of concerted and sustained baiting efforts, improvement of use directions (Besser and Pfeifer 1977), and bait stability (Cunningham 1983). The substitution of 4-AP HCl, the stabilized form of 4-AP, in the AFCC-99S product and the use of electric seeders mounted on all-terrain vehicles to broadcast baits from baiting lanes as done recently in North Dakota sunflower fields (Jaeger et al. 1983) appear to have solved the stability problem and partially solved the application problem. However problems with acceptance of chopped corn baits in sunflower fields by red-wings and their habit of breaking the large particles used in the AFCC-99S product still remain. The latter problems should be corrected within the next few years. The sunflower growing areas with perennial blackbird damage problems should then receive the kind of protection indicated in the 1973 study in Steele County.

As in corn, chemical frightening agents are more promising than attempts to reduce populations of blackbirds by poisons. Ripening sunflower seeds are preferred by blackbirds over all baits tried and getting a majority of blackbirds to accept a poison bait in a ripening sunflower field is even more difficult than in a ripening cornfield. Other chemical methods to protect sunflower also have many disadvantages. Repellent sprays appear to have little use in sunflower, because most of the repellent sprayed on heads in the soft seed stage falls on the florets which are sloughed off as heads ripen. Heads turn downward at later stages of maturity, effectively preventing the repellent from reaching the seedcoat which birds must open to feed on the kernels.

As discussed in the section on protecting protecting corn, chemosterilants--which could effectively reduce production of young and largely negate breeding habitats--might be employed profitably. However, costly chemosterilant research on birds now has low priority pending the outcome of programs using more direct methods of protecting sunflower.

## PEANUTS

Peanuts were planted on 1.3 million acres (0.4% of crop acres) and ranked 12th among the 19 major U.S. agricultural crops in 1982 (Statistical Reporting Service 1983a). Objective surveys of bird damage to windrowed peanuts have been conducted only in a three-county area near Lake Texoma in Oklahoma from 1969-1971. The estimates of damage ranged from $0.10 per acre in 1971 to $1.67 in 1969 and averaged $0.67 for the 3 years (Mott et al. 1972). Loss estimates for the 28,000 acres grown in these years averaged $19,000 per year. Since this area had high bird numbers and many small fields, damage to peanuts is likely to be much less than this on the average acre grown in the U.S. If damage on the average acre of peanuts grown is 1/10 of that found in the Oklahoma study, the national loss would be about $1.5 million at the average price for peanuts during the 1973-82 period.

The Common Grackle caused most of the damage in Oklahoma (Fig. 30). Flocks of brown-headed cowbirds and red-winged blackbirds also consumed windrowed peanuts regularly when shells were very dry. Blue jays, meadowlarks, crows, and Franklin's gulls also fed on peanuts. No information is available on the amount of peanuts a bird is able to consume daily.

In Oklahoma damage assessments, both the number of pods opened by birds and the number of pegs where pods had been removed by birds were counted on four 10-foot sections of windrowed peanuts per field and then the weight of the average peanut for each field sampled was determined (Mott et al. 1972) (Fig. 31). Multiplication of pods damaged per plot, the weight of the peanut (in lb) X the reciprocal of the fraction of an acre sampled per plot yielded an estimate of pounds lost/acre.

### Protection of Peanuts

The cultural practice most likely to circumvent damage is a quick and early harvest of windrowed peanuts. Losses of windrowed peanuts to birds of only $0.02 per acre were recorded in Oklahoma in October, but in the same area losses mounted to $2.38 per acre in November when large numbers of migrant grackles arrived (Mott et al. 1972). Early planting to miss major blackbird migration is, of course, advised. Any practice to hasten drying, such as turning windrows after rains and use of driers to allow earlier harvest will reduce bird damage.

Patrol of fields, under heavy attack by blackbirds, with .22 rifles and shotguns is cost-effective. Scarecrows are sometimes effective against crows, but are less effective against blackbirds. Gas-powered exploders are effective for preventing bird damage, particularly in small fields surrounded by woods, the kind of field likely to sustain the most serious damage. Because windrowed peanuts are often exposed to birds for

Fig. 30. Flocks of common grackles cause most of the damage to windrowed peanuts in Oklahoma. (Photo by Donald F. Mott)

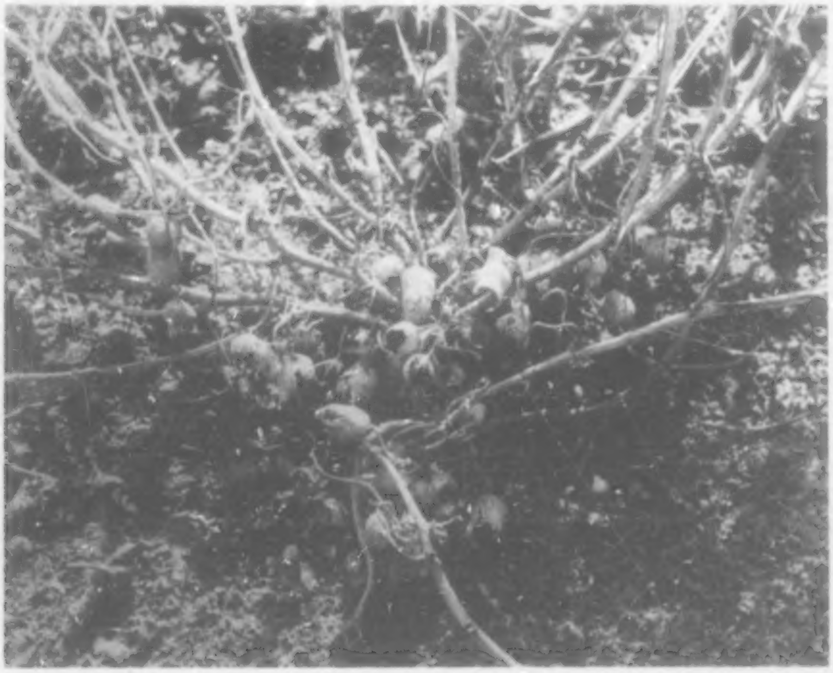


Fig. 31. To assess loss of windrowed peanuts from birds, pods opened by birds and pegs where birds have removed the pods are counted. (Photo by the author)

3-7 days, birds are less likely to become accustomed to exploders in peanut fields than in many other crops. The short damage season allows growers to shift an exploder from one small field to another enabling growers to sometimes share the cost of an exploder. In large fields, several exploders may be cost effective.

Baits treated with the chemical frightening agent, 4-AP, were effective for frightening blackbirds from windrowed peanut fields. In a few fields, where more than 1,000 blackbirds per acre were repeatedly seen, it was necessary to distribute the bait in small piles rather than broadcasting it as is the normal practice, because the first waves of blackbirds sometimes consumed all broadcasted baits before leaving. This left the field unprotected for attacks by subsequent flocks. 4-AP is not registered for use in peanut fields at present, and its development awaits a demonstration of sufficient need. No other chemical agent has been considered for the peanut problem.

## SOYBEANS

Soybeans were planted on 72 million acres (19.9% of crop acres) and ranked third among the 19 major agricultural crops in the U.S. in 1982 (Statistical Reporting Service 1983a). Bird damage to sprouting, ripening, and mature soybeans is negligible except under unusual circumstances.

## FLAXSEED

Flax was planted on 0.9 million acres (0.2% of crop acres) and ranked 15th among the 19 major agricultural crops in the U.S. in 1982 (Statistical Reporting Service 1983a). Flaxseed was not found in the stomachs of the 702 red-winged blackbirds collected at all seasons in northern South Dakota in the heart of the flax-producing region (Mott *et al.* 1972). Flax is the alternate crop most often recommended to Dakota and Minnesota growers suffering blackbird damage to grains and other oilseed crops.

## FRUIT CROPS

Fruits were grown on 3.6 million acres (1.1%) of U.S. cropland in 1978 (Bureau of Census 1978). Non-citrus fruit was grown in orchards and vineyards on 2.2 million acres, citrus on 1.3 million acres, and berries on 129,000 acres in 1978. Intensity of bird damage to certain kinds of ripening fruits, in terms of the proportion of the crop lost and growers suffering heavy losses, is likely greater than in any other group of crops grown in the U.S. (Stone 1973b). Bird damage to grapes, cherries, and blueberries each exceeds $1 million in the U.S. (Appendix A). Smaller losses to birds have been recorded for ripening apples, strawberries, and figs. Removal of buds by birds is occasionally a problem on apricot, pear, peach, plum, prune, and nectarine trees. More than 100 species of birds damage ripening fruit. Many of these species are among those most esteemed for their aesthetic values. This is an important consideration when seeking approaches for reducing damage.

## GRAPES

A total of 762,000 acres of grapes was grown in the U.S. in 1978 (Bureau of Census 1978). Wine grapes made up 41% of the acreage in 1972, raisin grapes 38%, table grapes 15%, and 6% were used for juice and other products(Crase *et al*. 1976). In an objective survey in nine coastal counties of central California, bird damage to wine grapes was estimated at $0.75 million in 1973, and losses to birds of wine, table, and raisin grapes in all of California were projected to exceed $3 million in 1973(DeHaven 1974a). In a questionnaire survey of 375 grape specialists in 13 States, the nationwide losses of grapes to birds was estimated to be at least $4.4 million in 1973 (Crase *et al*. 1976). Starlings, finches, and sparrows were the most important species damaging grapes. Robins, bluebirds, and waxwings caused less widespread damage. However, at least 23 other species were reported to damage grapes. In a statewide questionnarie survey of grape growers in New York in 1983, growers estimated losses, chiefly to starlings and robins, at 7% of the crop (Seamans and Caslick 1983).

Birds both pluck and peck grapes. Larger birds, such as starlings and robins, tend to pluck whole grapes from the bunch, whereas smaller birds, such as finches and bluebirds, tend to peck holes in a grape (Fig. 32). The amount of damage an individual bird can cause in a grape vineyard is also surprising. Caged starlings damaged 2.2 ounces of wine grapes per bird per day, caged robins 2.1 ounces per day, and caged house finches 0.6 ounces per day (Tobin 1982) (Appendix B).

Assessment of bird damage to grapes by growers, to enable them to determine what protection costs may be affordable, can be rather quickly done by checking the damage incidence or proportion of bunches damaged and then using this to estimate the probable percentage of crop lost from Appendix K (DeHaven 1981; DeHaven and Hothem 1981). A sample of 200 or more bunches chosen randomly throughout the vineyard is recommended. Appendix K was developed during surveys of California wine grapes, thus it may be less accurate for damage to other types of grapes and for grapes grown in other states.

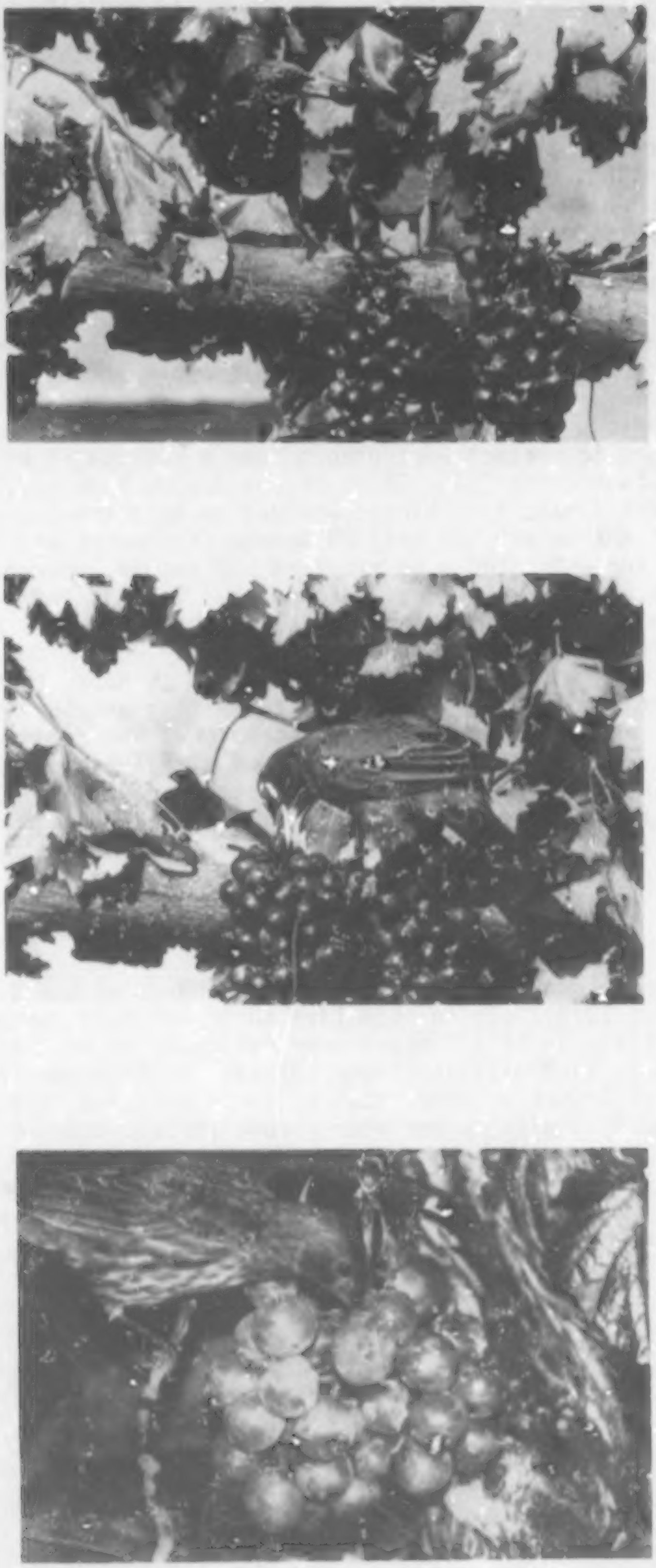


Fig. 32. Large birds such as starlings (top) and robins (middle) pluck whole grapes, whereas small birds such as house finches (bottom) tend to peck holes in them. (Photos by R. L. Hothem and R. W. DeHaven)

## Protection of Grapes

Early harvest is the only cultural method that greatly reduces damage. Exploders, shooting, electronic sound devices, trapping, reflectors, and netting are mechanical methods that are currently used by grape growers, but only 10% of 149 respondents in a 1973 survey thought any of these were very effective (Crase et al. 1976). Properly deployed netting for small vineyards is probably a notable exception, but netting is expensive (Seamans and Caslick 1983). Kites, imitating flying hawks, suspended from helium-filled balloons have been tried recently with some success in protecting vineyards, but costs have been high for the amount of crop saved (Hothem and DeHaven 1982).

A repellent spray of methiocarb, at 2.7 to 3.0 lb a.i. per acre, has been successfully used to protect wine grapes from a variety of birds in New York, in Oregon, and California (Fig. 33). In one Oregon vineyard, the untreated area received 77% damage from birds, whereas an area treated with three applications of methiocarb had only 2% damage (Hothem et al. 1981). In a New York vineyard, the untreated area received 51% damage, whereas an area treated with methiocarb every 2 weeks until harvest had only 3% damage (Zabadal and Hothem 1979). The cost of methiocarb applications on grapes have been $43-48 per acre per treatment and thus this repellent may not be cost-effective in all vineyards (Hothem et al. 1981). However, it is hoped that costs can be substantially reduced by such practices as treating only every second or third row of grapes, treating only the uppermost bunches where damage is usually greatest, and treating only those portions of vineyards most susceptible to damage (Zabadal and Hothem 1979). Fifteen states have obtained 1-year emergency exemptions to use methiocarb. Final federal registration is pending. However, see page 90 for a recent development in the registration status of methiocarb for fruit protection.

## CHERRIES

Cherries were grown on 129,000 acres of orchards in the U.S. in 1978 (Bureau of Census 1978). In an objective survey of bird damage to tart cherries in Michigan in 1972, losses were estimated to be 7.4% to 17.4% of the crop worth $1.8 to $4.3 million (Stone 1973a). If Michigan losses are representative of losses in other states, birds may cost tart cherry growers between $2.2 and $5.4 million per year (Stone 1973a). Losses in sweet cherries are probably higher than in tart cherries, since the former are vulnerable to birds for a longer period of time, and may be preferred because of their higher sugar content. At present, no data are available on bird damage to sweet cherries.

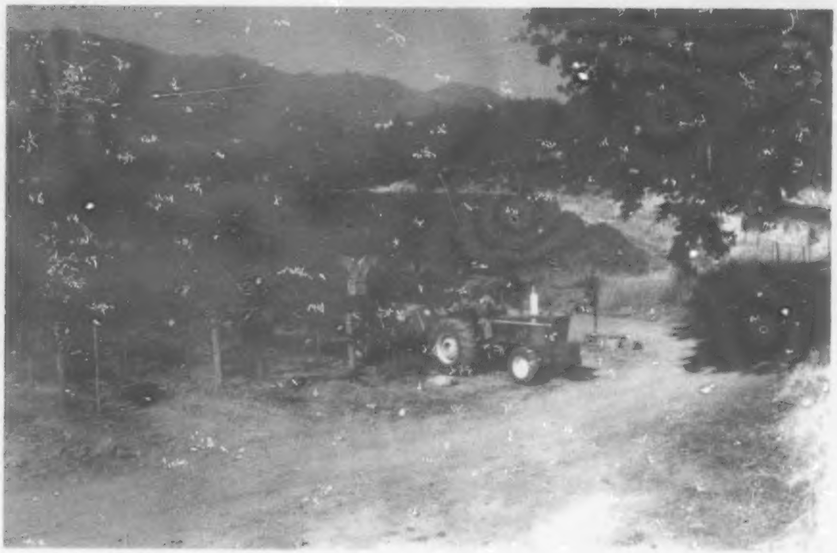


Fig. 33. A repellent spray of methiocarb has been used to successfully protect ripening wine grapes, such as these being treated near Calistoga, California. (Photo by Richard W. DeHaven)

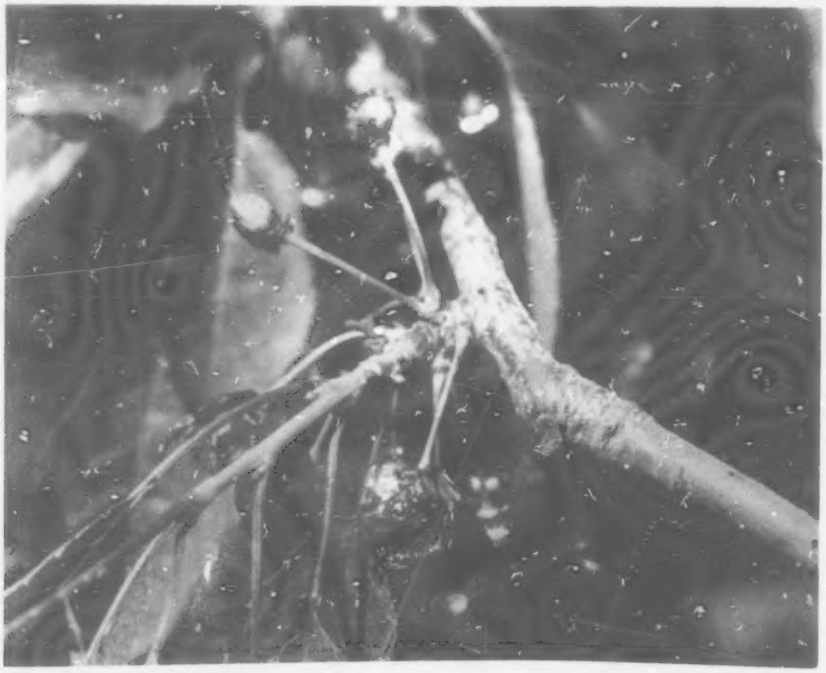


Fig. 34. Many species of birds damage ripening fruits, and cherries are perhaps the most extensively damaged of all. As with grapes, larger birds pluck whole cherries and smaller birds peck and remove the pulp leaving the stone attached to the stem. (Photo by Joseph L. Guarino)

Sweet cherry production in the U.S. is about 50% greater than that of tart cherries (Statistical Reporting Service 1983a). If damage to the U.S. cherry crop is the minumum percentage found in Michigan tart cherries in 1972, bird losses to cherries in the 1979-82 period are estimated at $10.9 million based on the average price paid for cherries during the 1973-82 period.

Starlings, robins, and orioles caused most of the damage in Michigan tart cherry orchards, but grosbeaks, catbirds, waxwings, grackles, bluejays, and woodpeckers were also involved (Stone 1973a; Guarino and Stone 1973; Guarino et al. 1974). House finches are an important species damaging sweet cherries in the Western U.S. (DeHaven et al. 1979). Larger birds, such as starlings and woodpeckers, tend to pluck whole cherries from stems, whereas smaller birds, such as house finches and waxwings, tend to peck holes in the skin of the cherry (Fig. 34).

Assessment of losses can best be made by marking a given number of unripe cherries in random locations in a tree and on random trees in an orchard. A small piece of flagging tape has been used to delineate 50 cherry groups, and sample sizes of 40 trees per orchard and 3 groups per tree have been used (DeHaven et al. 1979). Top, bottom, and interior portions of trees should be sampled separately as top portions usually have the most damage. It is often more efficient to sample top portions more intensively. The percentages of stems without cherries and pecked cherries at harvest equal the total lost.

## Protection of Cherries

Ecologically, the practice of planting wild fruits to lure birds away from cultivated cherries has been employed for centuries but it has never been tried widely in the U.S. (McAtee 1909). Essential to the success of decoy trees is that they be an early bearing species, since wild fruits are often scarce during the period that birds feed cultivated cherries to nestlings or fledglings. Fortunately, the U.S. has a species of decoy tree that bears fruit early and is a favorite of fruit-eating birds, the mulberry (Morus rubra). Either native or cultivated mulberries can be grown in any region of the U.S. and bear well (McAtee 1909). Mulberries have been found in the stomachs of 44 species of U.S. birds (McAtee 1942). The effect of a systematic effort to plant mulberries and other early-fruiting trees and shrubs to reduce damage to cherries needs to be evaluated.

Shooting is the mechanical means most often resorted to by growers to protect their crop, but the species of birds damaging cherries, other than starlings, are not easily frightened. First brood starlings, which heavily damage cherries in the Pacific Northwest, can readily be taken in decoy traps; relief to cherry growers has been provided by starling trapping programs in the state of Washington (Larsen 1971) (Fig. 35). House finches can also be successfully trapped in cherry orchards in decoy traps. A portable, inexpensive, hoop net trap for house finches has been designed and more than

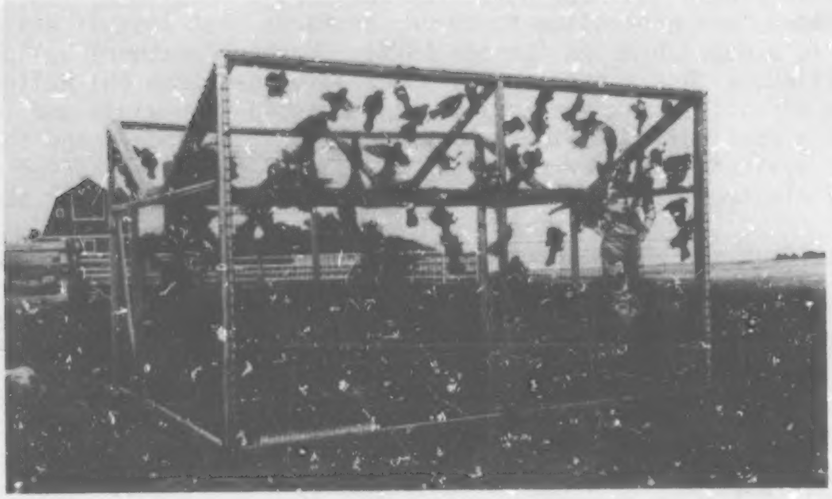


Fig. 35. First brood starlings can readily be taken in small Modified Australian Crow (MAC) traps, such as the one above. (Photo by John W. DeGrazio)

Fig. 36. A repellent spray of methiocarb has been successfully used to protect cherries against a variety of bird species. (Photo by Olin E. Bray)

10,000 finches were taken with as many as 15 traps in 3 summers in blueberry plantings in Oregon and Washington (Larsen 1970). Helium-filled balloons provide short-term protection to cherry orchards, but loss of helium after a few days is a major problem (Larsen 1971). Larger (weather) balloons, also helium filled, with a raptor (hawk) model suspended from the balloon have been even more effective, but are subject to damage in high winds and loss of helium is a continuing problem (Anonymous 1979). Exploders and shell-crackers work well against damage by starlings (Larsen 1971) and amplified distress calls and electronically generated noise are also effective for starlings.

A repellent spray of methiocarb has been successfully used to protect cherries against a variety of birds in Michigan (Guarino and Stone 1973, Guarino et al. 1974) and in California and Washington (DeHaven et al. 1979) (Fig. 36). In these studies two to five times as many cherries were damaged by birds in untreated orchards as in those sprayed with a single treatment of 1.0 to 2.2 lb of methiocarb per acre. Methiocarb was federally registered as a bird repellent spray (as Mesurol® 75WP) for cherries in 1978 and its use at 2 to 4 lb a.i./acre in high damage situations has been cost-effective. However, see page 90 for a recent development in the registration status of Mesurol® 75 WP for protecting fruit from birds.

Only one other chemical has been used to control damage to cherries. It is the poison, strychnine. Its use on rape seed baits for house finches is permitted only in California.

## BLUEBERRIES

About 27,000 acres of cultivated (highbush) blueberries were grown in the U. S. in 1978 (Bureau of Census 1978). A nationwide questionnaire survey of losses to blueberries in 1972 indicated birds damaged about 5% of the crop, worth $1.6 to $2.1 million (Mott and Stone 1973). About 20,000 acres of wild lowbush blueberries were harvested in 1978 (Bureau of Census 1978), but damage estimates are not available.

Blueberries have been found in the stomachs of 93 species of U.S. birds (McAtee 1942). Starlings, robins, and common grackles are the species that cause most damage to highbush blueberries (Mott and Stone 1973). House finches, cedar waxwings, jays, mockingbirds, catbirds, brown thrashers, red-winged blackbirds, cowbirds, cardinals, woodpeckers, crows, meadowlarks and orioles are other species that are locally troublesome or occasionally feed on blueberries. Some bud damage by grosbeaks and house finches has also been reported.

Wild lowbush blueberries growing near tidal flats in Maine were heavily fed on by flocks of Herring Gulls (McClanahan 1939). Species, in addition to those listed for high-bush blueberries, that feed on lowbush blueberries in mountainous areas in New Hampshire are the Scarlet Tanager, Rufous-sided Towhee, and Bobolink (Bollingier et al. 1973).

Birds usually pluck blueberries, leaving only the fruit pedicel; few pecked berries will be observed, except where house finches are causing damage.

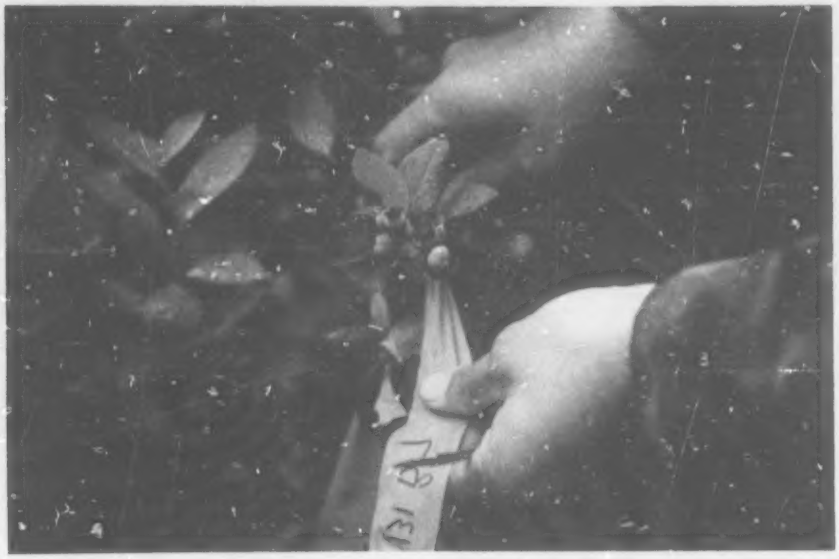


Fig. 37. Assessment of losses in blueberries can be done by marking groups of 10 green blueberries with a strip of flagging tape and appraising losses by birds when ripe. (Photo by Charles P. Stone)

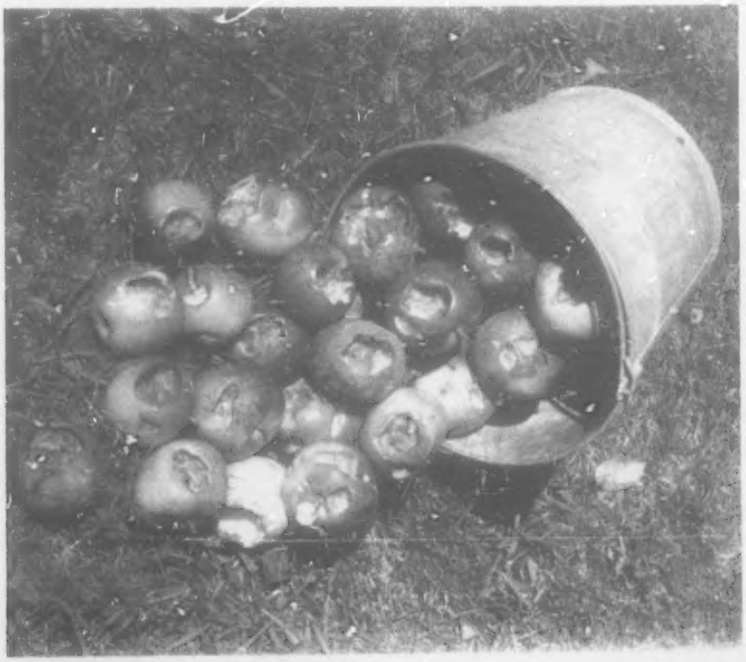


Fig. 38. Bird damage to apples is readily identifiable from beak punctures. These apples were damaged by crows in New York. (Photo by Donald A. Spencer)

Loss assessment can be made by marking groups of about 10 green berries at random locations within a planting, and resurveying them when they are fully ripe and before they drop (Stone et al. 1974). A small piece of flagging tape is useful for delineating groups (Fig. 37). Top and bottom portions of plants may be sampled separately as top portions are damaged more heavily by some species such as starlings and bottom portions more heavily by other species such as robins.

## Protection of Blueberries

Netting for small plantings is the most effective control method. However, costs of netting may average $300 to $500 per acre. In an Oregon study, pyrotechnics (shell-crackers and bird bombs) protected blueberries from starlings, robins, and cedar waxwings (de Calesta and Hayes 1979). In that study, starling distress calls protected blueberries against starlings, but distress calls of cedar waxwings caused waxwings to leave small plantings only 38% of the time. Exploders and shooting have been reported to be effective by some growers. Electronic noise generators also protect blueberries against starlings, but initial costs of purchasing equipment is high. In a Michigan study, an electronic noise generator successfully protected from 3 to 10 acres against starlings but was largely ineffective against 15 other species damaging blueberries (Pearson and Shake 1971). Kite-hawks suspended from balloons provide some protection to blueberries, especially during periods when wind increased the activity of the kite-hawks (Conover 1979). While removing overstory plants in wild lowbush areas, workers formed a kind of patrol that kept herring gulls from feeding on wild berries (McClanahan 1939).

Methiocarb is the only chemical that has been successfully used to protect ripening highbush blueberries against a variety of birds. In a Michigan study, $432 worth of blueberries per acre were estimated to have been saved by spraying bushes with 1.3 lb (about $23 worth) of methiocarb per acre (Stone et al. 1974). In that study 44% of the untreated blueberries were damaged, thus this 19-fold benefit:cost ratio might not be as great where damage is less severe. Methiocarb was also effective in decreasing damage to wild lowbush blueberries in a New Hampshire study (Bollengier et al. 1973). Methiocarb has recently been registered (as Mesurol$^{R}$ 75WP) for bird protection at rates of 1.5 to 2.0 lb a.i./acre in all blueberry-producing states except California and Massachusetts. However, see page 90 for a recent development in the registration status of Mesurol® 75 WP for protecting fruit from birds.

## APPLES

Apples were grown on 578,000 acres in the U.S. in 1978 (Bureau of Census 1978). Bird damage to apples is infrequently reported, since commercial apples are often harvested before they reach the stage of ripeness preferred by birds. In a 9-acre Connecticut orchard, a 3% loss was reported over a 3-year period; most damage was caused by bluejays, although crows, orioles, robins, and starlings also fed on apples (Mitterling 1965). The Lewis' Woodpecker occasionally damages apples in California (Koehler 1962).

Damage to apples is readily identifiable from beak punctures on the fruit (Fig. 38).

Apple growers have commented that bird damage is greater in dry seasons, therefore provision of a source of free water may be a cultural technique that allays damage (Mitterling 1967). Shooting and use of exploders and shellcrackers are sometimes cost effective; the use of netting and the use of electronic generated noise seldom are because of high initial cost. Chemical repellents may be cost effective, but are not likely to be registered because of the small acreage likely to be sprayed.

## OTHER FRUITS

A large variety of birds causes minor damage to peach, plum (prune), pear, avocado, strawberry, olive, apricot, nectarine, raspberry, blackberry, date, and persimmon crops. Peaches were grown on 263,000 acres, prunes on 141,000 acres, pears on 95,000 acres, avocadoes on 78,000 acres, strawberries on 46,000 acres, olives on 37,000 acres, apricots on 31,000 acres, nectarines on 23,000 acres, raspberries on 9,000 acres, blackberries on 5,000 acres, dates on 4,000 acres, and persimmons on 1,000 acres in the U.S. in 1978 (Bureau of Census 1978). Commercial peaches, plums, pears, avocadoes, apricots, nectarines, and dates are picked at stages of ripeness that are less preferred by birds. Bird damage to these fruits is largely limited to those left on trees for local consumption. This is not true of figs, olives, strawberries, raspberries, and blackberries. Starlings and other fruit-eating birds do locally serious damage to figs and sometimes to olives and persimmons in California. The Brewer's Blackbird causes heavy damage to figs on occasion (Neff 1937). The Band-tailed Pigeon occasionally damages berries (Crabb and Martin 1977).

Shooting, shellcrackers, exploders, amplified calls, electronically generated noise, and decoy traps all should decrease damage to figs, olives, and persimmons. In a 108-acre fig orchard in California, 13,000 house finches were taken in 4 large decoy traps during 17 months of trapping (Palmer 1970b). A repellent spray of methiocarb did not reduce damage to figs in the single instance reported (Crabb 1977).

Buds of apricots are damaged by goldfinches, white-crowned sparrows, and house finches (Fig. 39); house finches also damage buds of pears, peaches, plums, prunes, and nectarines. Some growers utilizing only decoy traps have successfully minimized disbudding damage by resident house finches, however, traps failed to provide adequate protection against nomadic flocks of house finches or migrating white-crowned sparrows, which may cause much damage during a 1 to 3-week period (Crabb and Martin 1977). During such invasions, a repellent spray of the affected area of an orchard may greatly alleviate such problems, however none are registered for this use. Methiocarb is an effective repellent for many species of birds, and especially effective against house finches. Addition of an adhesive, such as Rhoplex® AC-33 or Dow Latex® 512-R, to the wettable powder formulation of methiocarb (Mesurol® 75 WP) at about a 1 to 10 ratio of adhesive to active ingredient should be beneficial, if the problem persists for more than a week.

Strawberries are occasionally damaged by goldfinches, house finches and crowned sparrows, when they feed on the small seeds on the outer surface of the berry. These species respond poorly to scaring devices. House finches can be readily trapped, and in California, they can be poisoned. Waxwings, mockingbirds, orioles, and tanagers occasionally feed on strawberries. Densely placed flagging material deters attacks by these species on strawberries (Neff 1937). About 9,000 cedar waxwings were caught in a large decoy trap in 1 week at a site in California, then were released 20 miles away, and none that were tagged returned to the trap site, thus trapping may be successful for this species (Palmer 1970a). A chemical repellent spray would probably provide good protection to strawberries against all species, but again registration for the small acreage requiring treatment is not likely to be attempted.

Citrus crops such as oranges, grapefruit, lemons, and tangerines, although grown on 1.3 million acres in the U.S. in 1978 (Bureau of Census 1978), are seldom damaged by birds.

## NUT CROPS

Nuts were grown on 1.1 million acres or 0.3% of U.S. cropland in 1978 (Bureau of Census 1978). Pecans were grown on 457,000 acres (317,000 cultivated, 140,000 wild), almonds on 347,000 acres, English (or Persian) walnuts on 201,000 acres, pistachios on 29,000 acres, and filberts and hazelnuts on 22,000 acres in 1978.

Crows, jays, and woodpeckers frequently damage nut crops (Fig. 40). Blackbirds and magpies also damage nuts. Jays often cache far more nuts in nearby woodlands than they consume in an orchard. Almond buds are often damaged by cedar waxwings and house finches.

## PECANS

Pecans are fed on more heavily by birds than any other commercial nut, because they are grown in more States and are the only commercial nut grown in many states. No national surveys have been made of bird damage to pecans. Damage within a state varies greatly annually depending upon the amount of mast produced in local woodlands. Hence in years of low pecan production, bird damage to pecans is likely to be more severe. Bird damage to pecans in four Louisiana parishes was estimated to be $579,000 in 1974 (Murray 1975). The Oklahoma Pecan Commission estimated losses to birds in that state at about $700,000 annually (G. Couch pers. comm. 1977). In an average year, damage to pecans nationally is estimated to be about $10 million (Hall 1984).

Fig. 39. House finches have removed most of the flower buds from the upper branches of this California apricot orchard. (Photo by Johnson A. Neff)

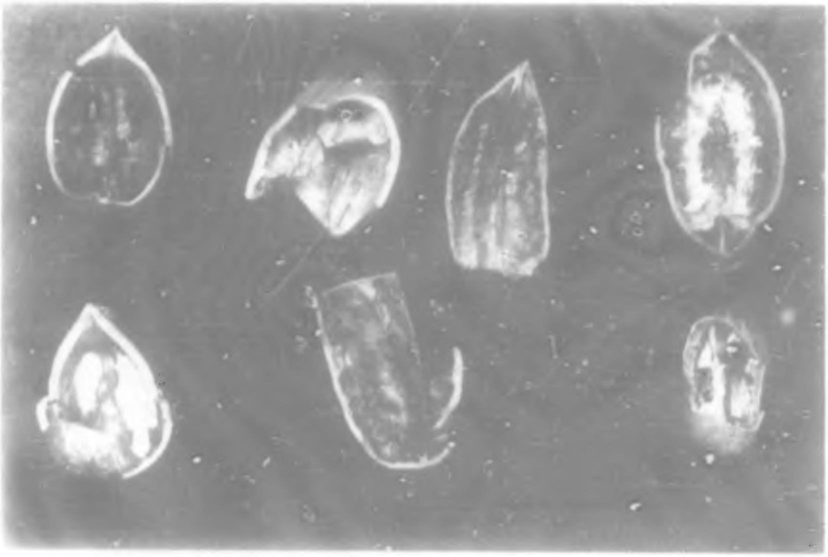


Fig. 40. Pecans damaged by blue jays (left), crows (center), and woodpeckers (right). These species are most frequently involved in damage to pecans. (Photo by T. C. Hall)

Scaring methods such as shooting and use of shellcrackers, exploders, amplified calls, and electronically generated noise are all effective in protecting pecans from crows. They are usually ineffective against blue jays. Killing blue jays lessens damage, but federal and state kill permits are required. The chemical frightening agent, 4-aminopyridine (4-AP), on whole corn baits placed under pecan trees is effective against crows (Wilson 1974); this use has been registered in Louisiana. Repellent sprays of methiocarb have been tried as a combined bird protectant and insecticide treatment, but results have been inconsistent (Hall 1984).

## OTHER NUTS

Crows and jays caused locally serious losses in English walnut and almond plantings in California (Neff 1937) and filbert plantings in Oregon (D. F. Mott, pers. comm. 1983). The Common Crow appeared to favor English walnuts and the Scrub Jay almonds (Neff 1937). The Acorn Woodpecker also damages walnuts and almonds (Koehler 1962). Pistachios are also heavily damaged by crows and jays at times. In 1966, the yield from a 1.5-acre pistachio crop in Tulare County, California was destroyed by 40 crows in 5 days and almond growers in this county reported losses of over $85,000 in one season (Simpson 1972). Bird damage to nuts is readily identifiable by shell fragments and bird droppings. Assessment of losses can probably be made by flagging and counting the number of nuts in clusters when nuts are green and again before they fall.

The scaring devices mentioned for protecting pecans will protect other kinds of nuts from crow damage. Shooting feeding scrub jays, after obtaining proper permits, was a preferred method for reducing nut damage in California (Neff 1937). In recent experiments, in Tulare County, California, whole corn baits treated with 3-chloro p-toluidine hydrochloride (DRC-1339) were successfully used to kill crows damaging nuts and pistachio nut meat baits treated with this chemical were successfully used to kill scrub jays raiding pistachio plantings (Simpson 1972). DRC-1339 is not yet registered for use against crows and jays damaging nut crops. A chemical frightening agent may also prove useful for protecting walnuts, almonds, pistachios, and filberts from damage by crows and jays.

## VEGETABLE CROPS

Vegetable crops were grown on 2.7 million acres or 0.8% of U.S. cropland in 1978 (Bureau of Census 1978). Fourteen kinds of vegetables were grown on more than 10,000 acres in 1978, led by tomatoes with 425,000 acres, green peas with 364,000 acres, lettuce with 253,000 acres, watermelons with 181,000 acres, and onions with 144,000 acres.

Vegetables crops are seldom seriously damaged except in the seedling stage. In a 1974 survey of vegetable growers in 21 California counties, growers listed damage to seedlings in the following order of importance: sprout pulling, taking seeds, and grazing sprouts (DeHaven 1974b). Damage to vegetable seedlings in the 21 California counties was estimated at $648,000 by 96 large growers, but some losses of seedling grains and sugar beets were included in this estimate.

Lettuce is the vegetable crop that generally receives the most bird damage in California and Arizona (Fig. 41). The Horned Lark is the chief species involved, but various sparrows, such as the White-crowned Sparrow and the Golden-crowned Sparrow, are sometimes locally important. The Water Pipit, Western Meadowlark, and Brewer's Blackbird are other species that attack sprouting lettuce (Neff 1937). Other vegetables that are damaged in the seedling stage are sugar peas, various kinds of beans, Brussels sprouts, radishes, broccoli, carrots, spinach, beets, cabbage, turnips, squash, melons, tomatoes, cucumbers, and onions (Neff 1937; DeHaven 1974b; Boudreau 1975). Birds damaging these other vegetable seedlings are similar to those damaging lettuce seedlings, with the Horned Lark of primary importance.

## Protection of Vegetable Crops

A number of cultural techniques, such as providing an alternate food, may lessen damage. An instance was cited where a grower burned a large patch of weeds near a newly seeded cantaloupe field being damaged by horned larks and the larks then fed on these newly exposed seeds and did no further damage (Boudreau 1975). In another instance a grower planted a narrow strip of safflower on the perimeter of a lettuce field and horned larks fed on the safflower rather than the lettuce seedlings (Boudreau 1975). Removal of brush piles on the borders of vegetable fields should lessen damage by sparrows that use the piles for loafing cover.

Few of the species that regularly feed on vegetable seedlings are easily repelled by most scaring methods that depend on noise alone and patrol of fields is sometimes cost prohibitive. Exploders were reported to be effective for horned larks damaging lettuce fields (Koehler 1962). In some cases, growers have achieved good protection using shell-crackers or bird bombs (Crabb and Martin 1977). Stakes with fluttering flags have been reported to be effective against damage by horned larks, but a flag about every 20 to 25 feet was required to protect a field against persistent attack (Neff 1936). Broadcast of amplified alarm calls of the species causing damage is effective in protecting some vegetable crops (Boudreau 1975), but equipment costs are high. Efficacy of the alarm calls may be increased by interspersing the alarm calls with hunting calls of avian predators (Pearson et al 1964). Many house sparrows can be captured in decoy traps (Royall 1969), but reinvasion of the area is often a problem.

READEX FICHE

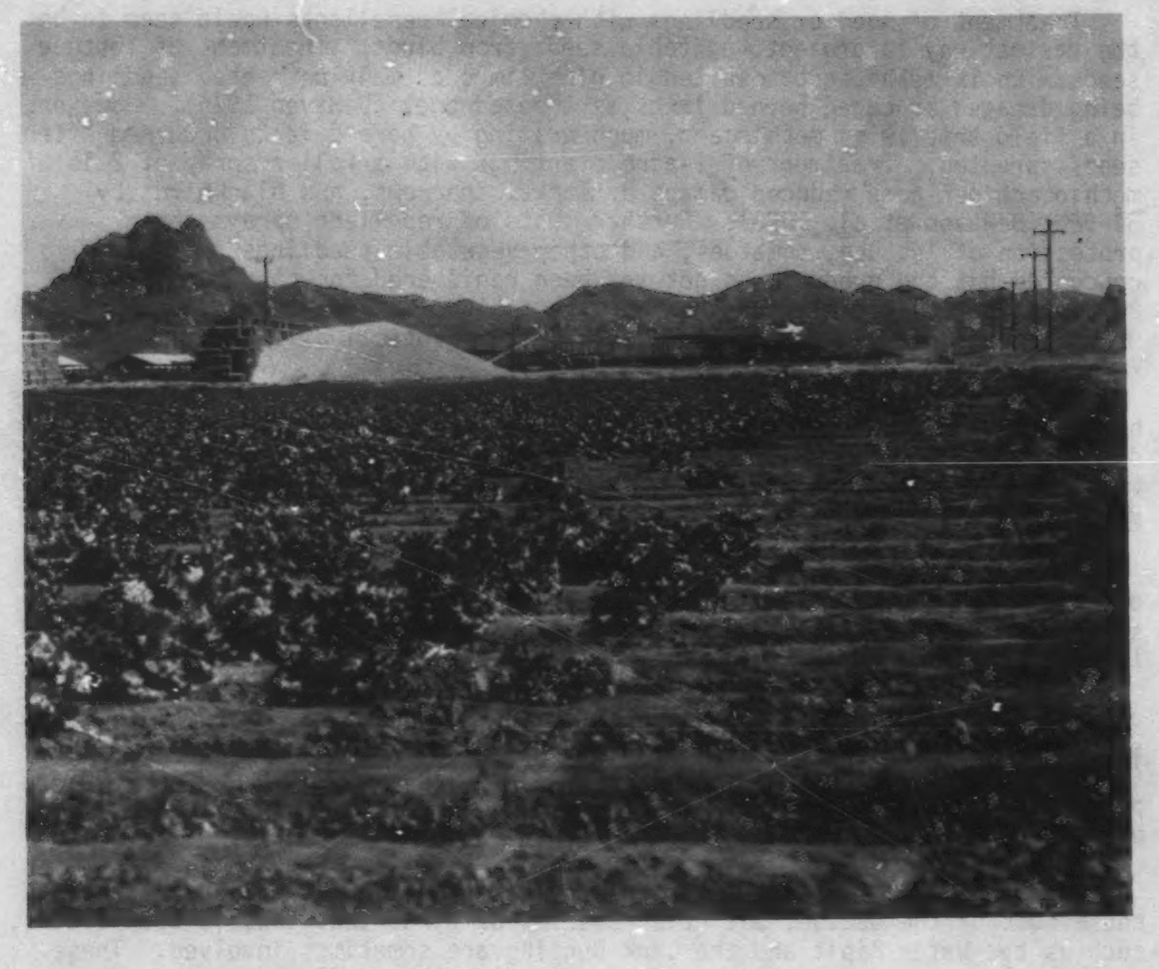


Fig. 41. Lettuce is the vegetable crop that receives the most serious bird damage in California and Arizona. Bare areas in this Arizona lettuce field were caused by birds feeding on plantlets when they emerged, several months earlier.(Photo by Joseph L. Guarino)

Raptor-mimicking kites suspended from helium-filled balloons may have potential as an effective means of frightening birds from newly seeded and sprouting vegetables. Although results were inconclusive, in initial trials of this device in Arizona, birds may have been frightened from the adjacent untreated plots as well as the plots with kites (DeHaven and McAuley 1981). Many lettuce growers are presently trying kites suspended from 20+-foot polyvinyl chloride poles.

Treatment of seed or seedlings with chemical repellents would seem to be the easiest way to protect vegetable seeds from birds. Treatment of lettuce seeds with 1% methiocarb resulted in nine times as many untreated seedlings being damaged by caged horned larks as treated ones (DeHaven 1976). However, in a field trial with methiocarb, much grazing by horned larks occurred after seeds sprouted. Treatment of 1-acre plantings with a foliar spray of 2 lb of methiocarb per acre reduced damage by larks, sparrows, and blackbirds by 54-96% (DeHaven et al. 1976). Further tests of repellent sprays for protection of lettuce, tomatoes, and other vegetable seedlings are being conducted but the product has not yet been registered for these uses. Broadcasting additional seed treated with a high level of methiocarb over normal seeded plantings may afford even better protection.

Poisoning horned larks with strychnine in lettuce fields in California has been practiced for several decades. Although many birds have been killed, the degree of protection obtained has never been measured.

## ROOT CROPS

Potatoes and sugar beets are two of the 14 U.S. agricultural crops grown on a million or more acres. Potatoes were grown on 1.3 million acres and sugar beets on 1.1 million acres (0.4 and 0.3% of U.S. cropland) and ranked 11th and 13th among U.S. crops in 1982 (Statistical Reporting Service 1983a).

The Sandhill Crane is the only bird reported to damage potatoes; they sometimes damage potato crops in the mountain valleys of southeastern Idaho (C. H. Lostetter, pers. comm. 1969). Small acreages of grain "lure" crops planted in congregating areas at game refuges would likely alleviate this problem (Knittle and Porter, in prep.).

Sugar beets in the seedling stage are damaged by birds. Horned larks cause most of the damage, but other species of birds that inhabit open fields, such as the Water Pipit and the Lark Bunting are sometimes involved. These species graze on new plantlets, often uprooting the seedlings.

Methods for controlling horned lark damage to sugar beet seedlings are similar to those for lettuce and other vegetable seedlings. Repellent seed treatments and foliar sprays appear to be less effective for sugar beets than for lettuce; in cage tests, a 1% methiocarb seed treatment reduced horned lark damage to sugar beet seedlings by only 51% compared to 88% for lettuce seedlings (DeHaven 1976). In small plot tests in California, a 4-lb/acre foliar application of methiocarb failed to protect sugar beet seedlings being damaged by horned larks (DeHaven et al. 1980). This prompted investigators to recommend repellent trials wherein (a) the seed be treated before planting, (b) that additional treated seed be broadcast on the soil surface as bait, and (c) that fields be sprayed by air at the start of seedling emergence.

## HAY CROPS

Sprouting alfalfa is the only hay crop seriously damaged by birds. Although grown on 26 million acres (7.3% of U.S. cropland) in 1978 (Bureau of Census 1978), alfalfa is seldom seriously damaged by birds except in a few areas bordering deserts in the southwestern U.S. Horned larks, white- and golden-crowned sparrows, and starlings are usually responsible. Treatment of seed with repellent seed treatments, spraying the emerging plantlets with repellents, or use of frightening methods are possible solutions to this problem.

## FEED GRAINS

Bird damage to the grains produced on 180 million acres of U.S. cropland does not stop when the grain is harvested. These grains along with protein supplements are fed to cattle, hogs, and poultry in livestock feeding areas, where wintering congregations of granivorous birds sometimes cause serious losses.

Damage has been particularly severe at cattle feedlots in the semi-arid regions of the West where rations are continuously available to beef animals in open troughs (Besser et al. 1968) (Fig 42). Heaviest losses have been reported from Oregon, Idaho, Utah, and Colorado, the northern fringe of the starlings' winter range in the West. Here, natural preferred bird foods are scarce for several months during winter, especially when the ground is frozen or snow covers it, forcing birds to subsist primarily on livestock rations. Availability of livestock rations at feedlots allows some troublesome species to winter in northern regions that otherwise would be forced to migrate farther south. Damage is less at hog feeding areas where feed is usually supplied in flip-top self-feeders and feed is available to birds only when a hog is feeding or when the feeder is in disrepair. Major losses of rations at poultry feeding areas are infrequent, because poultry is usually fed in confinement, but losses can be severe where poultry feeds are continually exposed outdoors (Royall et al. 1967).

Only one objective survey of the monetary loss of livestock rations to starlings and blackbirds has been made. Losses in Tennessee in the winter of 1979-80 were estimated at $674,000 (Glahn et al. 1980). In that survey, estimates were believed to be maximum; however, they were far less than estimated in a subjective (opinion) survey wherein bird losses in Tennessee were estimated at $4.2 million in the winter of 1975-76 (Hobson and Geuder 1976).

Fig. 42. Bird damage at cattle feedlots in the semi-arid West, where rations are continuously available in open troughs, has been particularly severe. (Photo by Richard R. Wset)

The European Starling is responsible for most losses of livestock feed from troughs and often selects the more costly high protein supplements from rations (West and Besser 1977). All species of wintering blackbirds, principally the Common Grackle, Red-winged Blackbird, and Brown-headed Cowbird also feed at livestock feeding areas in large numbers, but obtain much of their food from grains spilled or wasted by livestock feeders or their animals, or from undigested grain in cattle manure. The House Sparrow and the feral Rock Dove are present at many feeding areas and also take some food from troughs. Other species, such as the Mourning Dove, are a problem locally.

Losses of livestock rations can be estimated by determining the amount of ration that various species of birds are able to consume and then determining what percent of their diet consists of rations. In Colorado from 1960-66; the costs were estimated at $84 per 1,000 wintering starlings and $2 per 1,000 wintering red-winged blackbirds (Besser et al. 1968). Feed costs today are more than double the $0.03 per pound estimated cost of livestock rations consumed by starlings and the $.015 per pound for rations consumed by blackbirds in 1968; updated cost estimates are $168 per 1,000 wintering starlings and $4 per 1,000 wintering red-wings. Since Colorado is on the northern fringe of the winter range of these species, damage by more southerly wintering populations should be substantially less--perhaps 50% less. The most comprehensive survey of the numbers of starlings and blackbirds wintering in the U.S. was made in the winter of 1969-1970. A total of 340 million wintering starlings and blackbirds were found in 674 roosts (Webb and Royall 1970). Starlings made up 20% of the population and blackbirds 80%. These authors believed that about 15% of the birds were not counted, thus about 80 million starlings and 320 million blackbirds were estimated to have wintered in the U.S. that season. If one assumed that nationally the average starling or blackbird is half as costly to feeders as a Colorado starling or blackbird, the combined national loss of rations to starlings ($6.7 million) and blackbirds ($640,000) wintering in the U.S. can be estimated at $7.3 million.

## Protection of Feed Grains

Prevention of loss of livestock rations to birds for small producers can sometimes be easily accomplished. Pulling feed wagons into buildings or covering them with tarpaulins denies birds access to ration stocks and averts one source of loss. Repair of self-feeder covers at hog lots is another. Where bird numbers are extremely large, exposing feeds at night eliminated the bird problem, but cattle fed at night showed slower weight gains (Crabb 1978). Feeding large pellets, 1/2-inch or more in diameter, greatly reduced starling feeding and feeding liquids or granular meals to reduce bird consumption of rations was also suggested (Twedt and Glahn 1982). Feeders may be able to substitute non-protein nitrogen sources such as urea, biuret, anhydrous ammonia, and diammonium citrate for the high protein supplements preferred by starlings; animal fecal matter can also be grouped with these sources. However, non-protein nitrogen sources can be toxic and livestock may reject feed containing excessive levels of non-protein nitrogen. Since these sources of nitrogen are of little nutritional value to poultry (Chavez et al. 1966) they should be poorly accepted by starlings.

Electronically-generated noise has been effective at cattle feedlots where starlings were the principal species causing losses (Pearson et al 1964). Exploders also frigthen birds for short periods, but these and other noise-making devices often lose effectiveness during the long period, up to 6 months in more northernly regions, that resident and migrant birds are troublesome at feedlots in areas where snow often covers the ground and the ground is often frozen.

Chemical agents are the preferred method of control for the most serious problems at livestock feedlots. Because of the long period that starlings visit lots (and some days feed almost entirely on livestock rations) an acceptable bait for this species can usually be found. For stable populations in December and January, baiting with the starling poison, 3-chloro-4-methylbenzamine HCl (DRC-1339; Starlicide®) has been very effective; a 1% concentration of DRC-1339 on poultry pellets, diluted with nine parts untreated poultry pellets, poultry crumbles, or trough feed was broadcast at the rate of about 20 lb/acre in aisleways, in occupied cattle pens, near the perimeter of pens, or other areas where starlings fed (Besser *et al*. 1967; Royall *et al*. 1967). The cost of Starlicide® is about 70 cents *per* pound and since *one* treated pellet is lethal, about 20 starlings can be killed per pound of bait broadcast under good baiting conditions. At $168 per 1,000 starlings removed, the benefit:cost ratio is about $5:$1. Much greater benefit:cost ratios can be attained by exposing baits in containers such as rubber pans or small troughs and placing these atop cattle self feeders and buildings where starlings are loafing (Fig. 43). When acceptance is good or excellent, kills may be as high as 200 birds per pound (Besser and Bray 1977; Glahn and Steffen 1978) and benefit:cost ratios approach $50:$1. Baiting large (10,000 or more) concentrations of starlings in pre-roosting or staging areas is also effective for reducing losses of livestock rations and far easier than baiting the many individual lots within range of a roost (up to 30 miles) (Fig. 44). From 50,000 to 150,000 starlings were removed from roosts by baiting staging areas in Colorado (West 1968b) and in Kentucky and Tennessee (Knittle *et al*. 1980). Broadcasting Starlicide® baits on agricultural lands *has not* yet been federally registered, but if the pre-roosting area is at a livestock feeding area, which is frequently the case, the area may be conventionally baited. It would be profitable for all livestock feeders within range of a large starling roost to pool their resources and bait one or more livestock feeding areas used as staging (pre-roosting) areas by starlings.

Another potential way to largely eliminate those starlings that feed in cattle rations would be to add Starlicide® pellets directly to the livestock ration. When caged starlings were exposed to cattle rations containing 1 pound of treated pellets per ton of ration, 90% of the starlings were killed within 3 days (West and Besser 1977). Development and registration of the method awaits sufficient interest by the livestock industry.

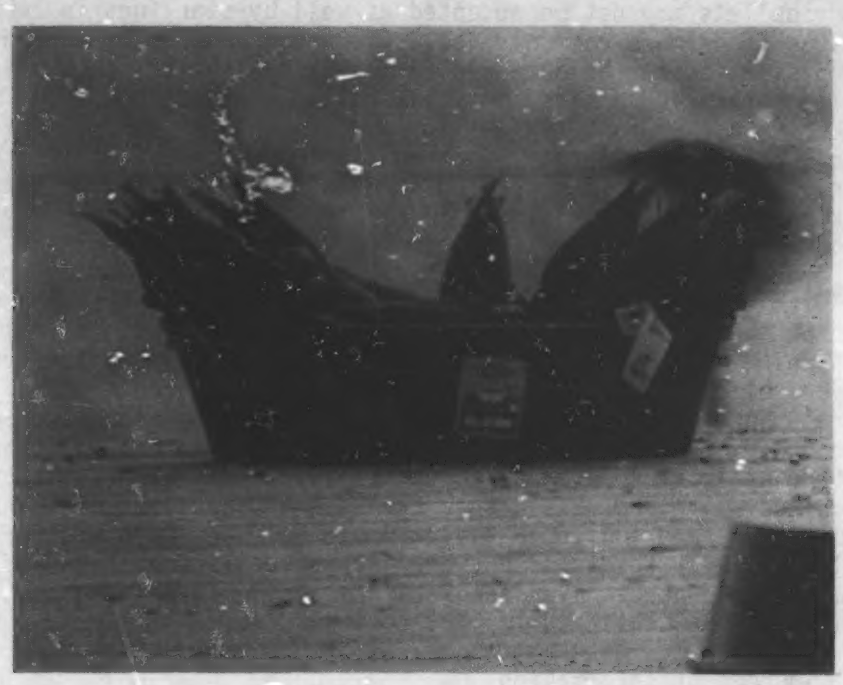


Fig. 43. Greatest cost: benefit ratios can be attained by exposing toxic pelleted baits for starlings in small containers such as these rubber pans in such locations as atop cattle self-feeders. (Photo by Jon F. Heisterberg)

Fig. 44. Baiting large concentrations of starlings near their roosts is sometimes more effective than trying to bait them at many individual livestock feedlots. At this Colorado roost, a snow fence was used to exclude livestock from bait troughs. (Photo by Richard R. West)

Poultry pellets may not be accepted as well by starlings in certain localities as foods more commonly fed. If enough interest is shown, state or federal registration can be obtained for additional baits, such as French-fried potatoes, raisins, or steam-rolled grains.

Chemical frightening agents, such as 4-aminopyridine (4-AP), are particularly useful against migrating starlings or migrating or wintering blackbirds in feedlots. In late fall or late winter, starlings may be present in livestock feeding areas for only a few days or weeks, and it is much easier to obtain quick relief for a problem by affecting a small percentage of starlings with a chemical frightening agent than to attempt to poison a larger percentage of these populations. Avitrol Corporation markets five kinds of baits containing 4-AP HCl for protecting livestock feeding areas from starlings and blackbirds. Four of these contain either corn chops, mixed grains, grain sorghum, or wheat, which are fair to good blackbird baits, but only one contains pelletized feed, often the preferred bait for starlings. These baits contain 1% 4-AP and are not "1-bait lethal" to starlings nor to most blackbirds. It is probable that the 3% 4-AP baits registered for protection of corn and sunflower fields would be more desirable for use against blackbirds at feedlots, but are not yet registered for feedlot use. 4-AP products for protection of feedlots are available only to pest control operators or persons certified in bird control.

## Additional Sources of Information

More recent and up-to-date information on bird damage control methods for a specific crop can often be obtained from many of the journals, conference proceedings, seminars, workshops, symposia, and unpublished report sources given in the References Cited section of this bulletin. About every two years, the Bird Control Seminar in Ohio, the Vertebrate Pest Conference in California, the Great Plains Wildlife Damage Control Workshop in Kansas, and the Eastern Wildlife Damage Control Conference in an eastern state are held. Proceedings of these meetings can be purchased. A table of contents of each meeting can probably be obtained without cost by writing the wildlife extension specialist at the state university hosting the meeting.

Much additional information can be obtained from several periodically up-dated wildlife damage control handbooks. The most notable of these are the Vertebrate Pest Control Handbook (available from the Department of Food and Agriculture, 1220 N. Street, Sacramento, California 95814) and the handbook of Prevention and Control of Wildlife Damage (available from the Wildlife Damage Control Specialist, 202 Natural Resources Hall, University of Nebraska, Lincoln, Nebraska 68583-0819).

## SUMMARY

Bird damage to U.S. agricultural crops is a problem that costs growers in excess of $100 million annually. However, serious losses are suffered by a small percentage of growers. Methods of protection are available for most crops against most species of birds, but are often less effective, particularly cost-effective, than desired. Some methods, particularly chemical methods, have been developed in the last two decades that have potential for alleviating the most serious damage to many major U.S. crops, particularly sprouting and ripening grains, and ripening oil seeds and fruit. However, most of these methods have not been widely employed and many require refinement by the grower for their special damage situations. For minor U.S. crops and those major crops less regularly damaged by birds, cost-effective control procedures often await identification of the loss to provide an incentive to industry to further develop potential damage alleviation measures.

## Acknowledgments

I thank J. W. De Grazio, J. L. Guarino, G. A. Hood, D. F. Mott, E. W. Pearson, and E. W. Schafer, Jr., for critical review of this manuscript.

References Cited

1. Anonymous. 1959. Report of Mississippi Agricultural Experimental Station (for 1958-59) 72: 24-25,53,70.

2. Anonymous. 1967. A report on the problem of damage to agricultural crops by wildlife in Maryland. Unpubl. rept., Maryland Dept. of Agric. 26pp.

3. Anonymous. 1979. Weather balloons and plastic hawk kites team to help reduce bird damage for cherry and grape growers. The Goodfruit Grower. March 1, 1979.

4. Anonymous. undated. A grower's guide to determining bird damage levels from damage incidence in sunflower fields and grape vineyards in California. Unpubl. rep., Denver Wildl. Res. Ctr. 5pp.

5. Bailey, L. H. 1925. Manual of cultivated plants. The MacMillan Company, New York, N.Y. 851pp.

6. Besser, B. R. and J. F. Besser. 1979. The comparable vulnerability of oil and non-oil sunflower to birds. Unpubl. Bird Damage Res. Rept. No. 110, Denver Wildl. Res. Ctr. 4pp.

7. Besser, J.F. 1973. Protecting seeded rice from blackbirds with methiocarb. Internat. Rice Comm. Newsl. 22(3):9-14.

8. Besser, J. F. 1976. Mesurol® 50% HBT for protecting sprouting corn from pheasants in Iowa. Unpubl. Bird Damage Res. Rep. No. 28, Denver Wildl. Res. Ctr. 9pp.

9. Besser, J. F. 1979a. Capability of red-winged blackbirds to damage ripening sunflower. Unpubl. Bird Damage Res. Rept. No. 113, Denver Wildlife Res. Ctr. 4pp.

10. Besser, J. F. 1979b. Notes on blackbird damage to sunflowers in Minnesota. Unpubl. rept., Denver Wildl. Res. Ctr. 7pp.

11. Besser, J. F. and D. J. Brady. 1982. Bird damage to ripening field corn in the United States, 1981. Unpubl. Bird Damage Res. Rep. No. 215, Denver Wildl. Res. Ctr. 17pp.

12. Besser, J. F., D. J. Brady, M. P. Marsh, J. L. Guarino, N. Shefte, E. W. Schafer, Jr., and D. L. Otis. 1981. Underestimation of sunflower losses to birds on near-harvest surveys. Unpubl. rept., Denver Wildl. Res. Ctr. 7pp.

13. Besser, J. F. and O. E. Bray. 1977. Baiting starlings with Starlicide® at livestock feeding areas in Laurel County, Kentucky. Unpubl. Bird Damage Res. Rept. No. 45, Denver Wildl. Res. Ctr. 16pp.

14. Besser, J. F., R. B. Brunton, D. J. Cunningham, and M. Duncan. 1977. The comparative effectiveness, safety, and economics of two methods of protecting sunflower fields from blackbird damage in North Dakota. Unpubl. Bird Damage Res. Rept. No. 42, Denver Wildl. Res. Ctr. 12pp.

15. Besser, J. F. and J. F. Cummings. 1975. Avitrol® FC Corn Chops-99S baits for protecting sunflowers from blackbirds in North Dakota, Minnestoa, and South Dakota, Unpubl. Rept. No. 59. Work Unit DF-102.3, Denver Wildl. Res. Ctr. 27pp.

16. Besser, J. F. and J. W. DeGrazio. 1985. Cost-benefits of baiting with 4-aminopyridine hydrochloride on baiting-lanes and evaluation of an insecticidal pretreatment for protecting ripening field corn from blackbirds, South Dakota, 1984. Unpubl. Bird Damage Res. Rept. No 339, Denver Wildl. Res. Ctr. 26 pp.

17. Besser, J. F. and E. F. Eastin. 1979. Bird damage to sprouting rice on the Gulf Coast of Texas and a possible method of utilizing Mesurol® for this problem. Unpubl. rept., Denver Wildl. Res. Ctr. 14pp.

18. Besser, J. F. and D. J. Elias. 1979. Methiocarb sprays for protecting grain sorghum from damage by house sparrows, Weslaco, Texas. Unpubl. Bird Damage Res. Rept. No. 107, Denver Wildl. Res. Ctr. 6pp.

19. Besser, J. F., and J. L. Guarino. 1977. Protection of ripening sunflowers from blackbird by baiting with Avitrol® FC Corn Chops-99S. Proc. Bird Control Seminar, Bowling Green, Ohio 7:200-203.

20. Besser, J. F. and R. V. Hanson. 1983. Evaluation of 4-aminopyridine hydrochloride baits on baiting lanes for protecting ripening field corn from blackbird damage, South Dakota, 1983. Unpubl. Bird Damage Res. Rept. No 295, Denver Wildl. Res. Ctr. 15pp.

21. Besser, J. F. and C. E. Knittle. 1977. Mesurol® 50% HBT for protecting sprouting corn from pheasants in Iowa and South Dakota. Proc. Bird Control Seminar, Bowling Green, Ohio 7:225-227.

22. Besser, J. F. and W. K. Pfeifer. 1977. Improvement of baiting methods for protecting ripening sunflower from blackbirds. Proc. Sunflower Forum 2:11-12.

23. Besser, J. F., J. W. DeGrazio, and J. L. Guarino. 1968. Costs of wintering starlings and red-winged blackbirds at feedlots. J. Wildl. Manage. 32(1):179-180.

24. Besser, J. F., J. W. DeGrazio, and J. L. Guarino. 1973. Decline of a blackbird population during seven years of baiting with a chemical frightening agent. Proc. Bird Control Seminar, Bowling Green, Ohio 6:12-14.

25. Besser, J. F., W. C. Royall, Jr., and J. W. DeGrazio. 1967. Baiting starlings with DRC-1339 at a cattle feedlot. J. Wildl. Manage. 31(1):48-51.

26. Bollengier, R. M., J. L. Guarino, and C. P. Stone. 1973. Aerially applied methiocarb spray for protecting wild lowbush blueberries from birds. Proc. Bird Control Seminar, Bowling Green, Ohio 6:216-220.

27. Boudreau, G. W. 1975. How to win the war with pest birds. Wildlife Technology, Hollister, CA. 174pp.

28. Bray, O. E., J. J. Kennelly, and J. L. Guarino. 1975. Fertility of eggs produced on territories of vasectomized red-winged blackbirds. Wilson Bull. 87(2):187-195.

29. Bridgeland, W. T. 1979. Timing bird control applications in ripening corn. Proc. Bird Control Seminar, Bowling Green, Ohio 8:222-228.

30. Bruggers, R., J. Matee, J. Miskell, W. Erickson, M. Jaeger, W. B. Jackson, and Y. Juimale. 1981. Reduction of bird damage to field crops in eastern Africa with methiocarb. Trop. Pest Manage. 27(2):230-241.

31. Bullard, R. W. 1979. New developments in bird resistant sorghum. Proc. Bird Control Seminar, Bowling Green, Ohio 8:229-233.

32. Bureau of Census. 1978. 1978 Census of Agriculture. Vol. 1. Summary and State Data, Part 51. United States. U. S. Dept. of Commerce, 510 pp and appendices.

33. Calvi, C., J. F. Besser, J. W. DeGrazio, and D. F. Mott. 1977. Protecting Uruguayan crops from bird damage with methiocarb and 4-aminopyridine. Proc. Bird Control Seminar, Bowling Green, Ohio 7:255-258.

34. Canadian Wildlife Service. 1982. Preventing bird damage to prairie crops. Can. Wildl. Serv., Winnipeg, Man. 19pp.

35. Caslick, J. W., L. O'Halloran, B. Meanley, and J. L. Seubert. 1963. An evaluation of blackbird decoy traps in the Arkansas rice belt. Unpubl. Spec. Rept., Work Unit F-31.2 Patuxent Wildl. Res. Ctr. 13pp.

36. Chavez, R., J. M. Thomas, and B. L. Reid. 1966. The utilization of non-protein nitrogen by laying hens. Poultry Sci. 45:547-553.

37. Conover, M. R. 1979. Response of birds to raptor models. Proc. Bird Control Seminar, Bowling Green, Ohio 8:16-24.

38. Crabb, A. C. 1977. A preliminary report on efficacy of methiocarb as an avian repellent in figs. Unpubl. rept., Univ. Calif-Davis, 9pp.

39. Crabb. A. C. 1978. Bird damage research at the University of California Davis. Proc. Vetebr. Pest Control Conf., Sacramento, Calif. 8:36-39.

40. Crabb, C. A. and L. R. Martin. 1977. Protection of California's agriculture from starling, house finch, pigeon, house and crowned sparrow damage: A review of applied and experimental techniques. In the colloquium on crop protection against starlings, pigeons, and sparrows, European and Mediterranean Plant Protection Organization, Jouy en Josas, France. Oct. 1977. pp 158-180.

41. Crase, F. T. 1974. An evaluation of methiocarb as a blackbird repellent when aerially applied to maturing rice. Unpubl. Rept. No. 48, Work Unit DF-102.3, Denver Wildl. Res. Ctr. 10pp.

42. Crase, F. T., C. P. Stone, R. W. DeHaven, and D. F. Mott. 1976. Bird damage to grapes in the United States with emphasis on California. U.S. Fish Wildl. Serv., Spec. Sci. Rept.--Wildl. No. 197. 18pp.

43. Cunningham, D. J. 1976. Evaluation of methiocarb as a chemical repellent for protecting windrowed wheat from damage by waterfowl. Unpubl. Bird Damage Res. Rept. No. 36, Denver Wildl. Res. Ctr. 5pp.

44. Cunningham, D. F. 1983. Avitrol bait formulation improved. Res. Info. Bull. 83-39. U.S. Fish and Wildl. Serv., Washington, D.C. 2 pp.

45. Cunningham, D. J. and C. E. Knittle. 1976. Evaluation of methiocarb as a chemical repellent for protecting windrowed grain from damage by waterfowl. Unpubl. Bird Damage Res. Rept. No. 9, Denver Wildl. Res. Ctr. 17pp.

46. Dambach, C. A., and D. L. Leedy. 1949. Prevention of crop damage by pheasants Trans. N. Am. Wildl. Conf. 14:592-603.

47. deCalesta, D. S. and J. P. Hayes. 1979. Frightening devices prevent bird damage. Pest Control 47(9):18-20.

48. DeGrazio, J. W. 1963. Methods of controlling blackbird damage to field corn in the vicinity of Sand Lake National Wildlife Refuge, South Dakota. Unpubl. rept., Denver Wildl. Res. Ctr. 77pp.

49. DeGrazio, J. W. 1964. Methods of controlling blackbird damage to field corn in the vicinity of Sand Lake National Wildlife Refuge, South Dakota. Unpubl. rept., Denver Wildl. Res. Ctr. 56pp.

50. DeGrazio, J. W. 1965. Methods of controlling blackbird damage to field corn in the vicinity of Sand Lake National Wildlife Refuge, South Dakota. Unpubl. rept., Denver Wildl. Res. Ctr. 43pp.

51. DeGrazio, J. D., J. F. Besser, J. L. Guarino and R. R. West. 1966. Control of blackbird damage to corn in South Dakota. Unpubl. Rept., Denver Wildl. Res. Ctr. 9pp.

52. DeGrazio, J. W., J. F. Besser, T. J. DeCino, J. L. Guarino, and R. I. Starr. 1971. Use of 4-aminopyridine to protect ripening corn from blackbirds. J. Wildl. Manage. 35(3):565-569.

53. DeGrazio, J. W., J. F. Besser, T. J. DeCino, J. L. Guarino, and E. W. Schafer, Jr. 1972. Protecting ripening corn from blackbirds by broadcasting 4-aminopyridine baits. J. Wildl. Manage. 36(4):1316-1320.

54. DeHaven, R. W. 1971. Blackbirds and the California ricr crop. Rice J. 74(8):7-8, 11-12, 14.

55. DeHaven, R. W. 1974a. Bird damage to wine grapes in central California, 1973. Proc. Vertebr. Pest Control Conf., Anaheim, Calif. 6:248-252.

56. DeHaven, R. W. 1974b. Bird damage to seeds and seedling crops in California--a questionnaire survey. Unpubl. Tech. Rep. No. 55, Work Unit DF-102.3. Denver Wildl. Res. Ctr. 21pp.

57. DeHaven, R. W. 1976. Additional cage tests with methiocarb for reducing horned lark damage to sugar beet and lettuce seedlings, Unpubl. Bird Damage Res. Rep. No. 8, Denver Wildl. Res. Ctr. 4pp.

58. DeHaven, R. W. 1981. Estimating bird damage to grapes from damage incidence. Res. Infor. Bull. 81-9, U. S. Fish and Wildl. Serv., Washington, D.C. 1p.

59. DeHaven, R. W. 1982. Bird damage to sunflower measured in three-state area for 1979 and 1980. Res. Infor. Bull. 82-30, U. S. Fish and Wildl. Serv., Washington, D.C. 2pp.

60. DeHaven, R. W., F. T. Crase, and J. L. Guarino. 1976. Field tests with methiocarb for reducing bird damage to lettuce and sugar beet seedlings. Unpubl. Bird Damage Res. Rept. No. 4. Denver Wildl. Res. Ctr. 7pp.

61. DeHaven, R. W., J. L. Guarino, F. T. Crase, and E. W. Schafer, Jr. 1971. Methiocarb for repelling blackbirds from ripening rice. Internat. Rice Comm. Newsl. 20(4):27-30.

62. DeHaven, R. W., and R. L. Hothem. 1981. Estimating bird damage incidence in wine grape vineyards. Am. J. Enol. Vitic. 32(1):1-4.

63. DeHaven, R. W., R. L. Hothem, and J. P. Skorupa. 1980. Effectiveness of Mesurol® sprays for reducing horned lark damage to germinating sugar beets. Unpubl. Bird Damage Res. Rept. No. 144, Denver Wildl. Res. Ctr. 10pp.

64. DeHaven, R. W., and T. J. McAuley. 1981. An evaluation of raptor-kite ballon devices for reducing damage by horned larks to sprouting lettuce. Unpubl. Bird Damage Res. Rept. No. 188, Denver Wildl. Res. Ctr. 8pp.

65. DeHaven, R. W., D. F. Mott, J. L. Guarino, J. F. Besser, C. E. Knittle, and E. W. Schafer, Jr. 1979. Methiocarb for repelling birds from ripening sweet cherries. Internat. Pest Control 21(1):12-14, 21.

66. DeLoughery, R. L. and R. K. Crookston. 1979. Harvest index of corn affected by population density, maturity rating, and environment. Agron. J. 71:577-580.

67. Delvo, H. W. and M. Hawthorn. 1983. Inputs, outlook, and situations. U. S. Dept. Agric., Economic Res. Serv., IOS-2, Oct. 1983, 23pp.

68. Dolbeer, R. A., C. R. Ingram, J. L. Seubert, A. R. Stickley, Jr., and R. T. Mitchell. 1976. 4-Aminopyridine effectiveness in sweet cor related to blackbird population density. J. Wildl. Manage. 40(3):564-570.

69. Dolbeer, R. A., A. R. Stickley, Jr., and P. P. Woronecki. 1978/1979. Starling, Sturnus vulgaris, damage to sprouting wheat in Tennessee and Kentucky, U.S.A. Protection Ecology 1:159-169.

70. Dolbeer, R. A., P. P. Woronecki, and R. A. Stehn. 1982. Effect of husk and ear characteristics on resistance of maize to blackbird (Agelaius phoeniceus) damage in Ohio, U.S.A. Prot. Ecol., 4:127-139.

71. Fairaizl, S. D. 1982. The North Dakota waterfowl lure crop pilot project: A summary report 1975-1980. Unpubl. rept., U.S. Fish and Wildl. Serv., Bismarck, N.D. 34pp.

72. Fox, G. J., D. E. Parfitt, and J. D. Brosz. 1982. Inheritance of blackbird resistance/tolerance in sunflower. Unpubl. Bird Damage Res. Rept. No. 226., Denver Wildl. Res. Ctr. 16pp.

73. Fried, L. A. 1940. The food habits of the ring-necked pheasant in Minnesota. J. Wildl. Manage. 4(1):27-36.

74. Glahn, J. F., J. F. Heisterberg, and D. J. Twedt. 1980. Distribution of bird depredations at livestock feeding operations in selected Tennessee counties, 1979-1980: an economic appraisal. Unpubl. Bird Damage Res. Rept. No. 173, Denver Wildl. Res. Ctr. 14pp.

75. Glahn, J. F., and D. E. Steffen. 1978. A preliminary evaluation of Starlicide® for reducing starling damage at dairy feedlots in Tennessee. Unpubl. Bird Damage Res. Rept. No. 88, Denver Wildl. Res. Ctr. 15pp.

76. Goodhue, L. D., and F. M. Baumgartner. 1965. Application of new bird control chemicals. J. Wildl. Manage. 29(4):830-837.

77. Guarino, J. L. 1967. Report of trip of Clarendon County, South Carolina, April 17-22, 1967. Unpubl. rept., Denver Wildl. Res. Ctr. 9pp.

78. Guarino, J. L., and J. E. Forbes. 1970. Preventing bird damage to sprouting corn with a carbamate repellent. New York Fish and Game J. 17(2):117-120.

79. Guarino, J. L., and C. P. Stone. 1973. A low-level treatment of the avian repellent, methiocarb, on ripening sweet cherries. Proc. Bird Control Seminar, Bowling Green, Ohio 6:24-27.

80. Guarino, J. L., W. F. Shake, and E. W. Schafer, Jr. 1974. Reducing bird damage to ripening cherries with methiocarb. J. Wildl. Manage. 38(2):338-342.

81. Hall, T. C. 1984. An evaluation of control techniques in pecan orchards in Oklahoma. Unpubl. Master's Thesis, Okla. State Univ., Stillwater, Okla. 68pp.

82. Hamza, M., B. Ali, I. El Haig, W. Bohl, J. Besser, J. DeGrazio, and R. Bruggers 1982. Evaluation the bird repellency of methiocarb. Malimbus 4:33-41.

83. Heisterberg, J. F. 1980. Comparing the bird repellent and phytotoxic properties of two registered seed corn treatments. Unpubl. Bird Damage Res. Rept. No. 181., Denver Wildl. Res. Ctr. 28pp.

84. Heisterberg, J. F. 1983. Keep birds out of sprouting corn. Progressive Farmer. May issue, p AA-2.

85. Heisterberg, J. F. 1984. Bird damage to sprouting corn in Kentucky and Tennessee. Proc. Southeastern Assoc. of Fish and Wildl. Agencies. (In press).

86. Heisterberg, J. F., and D. L. Otis. 1983. A change-over test design to compare relative efficacies of repellent seed corn treatments. Am. Soc. for Testing and Materials Spec. Tech. Publ. 817:98-109.

87. Henne, D. R., W. K. Pfeifer, and J. F. Besser. 1979. A revised estimate of bird damage to sunflowers in North Dakota in 1978. Unpubl. Bird Damage Res. Rept. No. 134. Denver Wildl. Res. Ctr. 6pp.

88. Hobson, R., and J. Geuder. 1976. Tennessee blackbird damage survey, October 1976. Unpubl. rept. Tenn. Crop Reporting Service, Nashville, TN. 3pp.

89. Holler, N. R., H. P. Naquin, P. W. Lefebvre, D. L. Otis and D. J. Cunningham. 1982. Mesurol® for protecting sprouting rice from blackbird damage in Louisiana. Wildl. Soc. Bull. 10(2):165-170.

90. Hothem, R. L. and R. W. DeHaven. 1982. Raptor-mimicking kites for reducing bird damage to wine grapes. Proc. Vertebr. Pest Conf., Univ. of Calif.-Davis. 10:171-178.

91. Hothem, R. L., D. F. Mott, R. W. DeHaven and J. L. Guarino. 1981. Mesurol as a bird repellent on wine grapes in Oregon and California. Am. J. Enol. Vitic. 32(2):150-154.

92. Imler, R. H., H. C. Gascon, and C. L. Horner. 1944. Fulvous tree duck depredations on rice in Louisiana. Unpubl. rept., Denver Wildl. Res. Ctr. 8pp.

93. Ingram, C. R., R. T. Mitchell, and A. R. Stickley, Jr. 1973. Hopper box treatment of corn seed with methiocarb for protecting sprouts from birds. Proc. Bird Control Seminar, Bowling Green, Ohio 6:206-215.

94. Jaeger, M. M., J. L. Cummings, D. L. Otis, J. L. Guarino, and C. E. Knittle. 1983. Effect of Avitrol® baiting on bird damage to ripening sunflower within a 144-section block of North Dakota. Proc. 9th Bird Control Seminar, Bowling Green, Ohio. 9:247-254.

95. Jordan, J. S. 1953. Consumption of cereal grains by migratory waterfowl. J. Wildl. Manage. 17(2):120-123.

96. Knittle, C. E. 1976. Distribution of blackbird damage in North Dakota sunflowers. Unpubl. Bird Damage Res. Rept. No. 2. Denver Wildl. Res. Ctr. 6pp.

97. Knittle, C. E., and J. L. Guarino. 1976. A 1974 questionnaire survey of bird damage to ripening grain sorghum in the United States. Sorghum Newsl. 19:93-94.

98. Knittle, C. E., J. L. Guarino, P. C. Nelson, R. W. DeHaven, and D. J. Twedt. 1980 Baiting blackbird and starling congregating areas in Kentucky and Tennessee. Proc. Verter. Pest Control Conf.,Fresno, Calif. 9:31-37.

99. Knittle, C. E., J. L. Guarino, O. E. Bray, J. L. Cummings, and M. R. Ouellette 1977. Protecting ripening sweet corn from blackbirds in Wisconsin with 4-aminopyridine. Proc. Bird Control Seminar, Bowling Green, Ohio 7:188-194.

100. Knittle, C. E., M. R. Ouellette, D. J. Cunningham, and J. F. Besser. 1976. Protection of ripening wheat from blackbirds with methiocarb in North Dakota. Unpubl. Bird Damage Res. Rept. No. 18, Denver Wildl. Res. Ctr. 9pp.

101. Knittle, C. E. and R. D. Porter. (In prep.) Waterfowl, ripening grain damage, and control methods: an overview.

102. Koehler, J. W. 1962. Linnets, horned larks, crowned sparrows, and woodpeckers. Proc. Vertebr. Pest Control Conf. Sacramento, Calif. 1:158-160.

103. Larsen, K. H. 1970. A hoop-net trap for passerine birds. Bird Banding 41(2):92-96.

104. Larsen, K. H. 1971. Bird control in orchards. Proc. Oregon Horticultural Soc. 62:64-68.

105. Linz, G. M., D. L. Vakoch, J. F. Cassel, and R. B. Carlson. 1984. Food of red-winged blackbirds (Agelaius Phoeniceus) in sunflower fields and corn fields. Canadian Field-Naturalist 98(1):38-44.

106. McAtee, W. L. 1909. Plants useful to attract birds and protect fruit. Yearbook of Dept. of Agric., Washington, D.C. pp185-196.

107. McAtee, W. L. 1942. Local bird refuges. U.S. Dept. Int., Conservation Bull. 17:1-17.

108. McClanahan. 1939. Protecting blueberries from damage by herring gulls. Wildl. Leaflet BS-141, U.S. Dept. Int. 4pp.

109. Meanley, B. 1971. Blackbirds and the Southern rice crop. U.S. Bur. Sport Fish. Wildl., Resource Publ. 100. 64pp.

110. Miears, R. J., W. Klussmann and B. Cook. 1964. Bird and crop 1963 survey summary. Unpubl. rept., Texas Ag. Ext. Serv., Texas A & M Univ., Austin, TX 9pp.

111. Miller, H. W. 1976. Crop depredation as a limiting factor. Pages 35-39. In Proc. 2nd Internat. Waterfowl Symposium, St. Louis, MO.

112. Mitchell, R. T., and J. T. Linehan. 1967. Protecting corn from blackbirds U. S. Fish Wildl. Serv., Wildl. Leafl. 476. 8pp.

113. Mitterling, L. A. 1965. Bird Damage on apples. Proc. Am. Soc. Hort. Sci. 87:66-72.

114. Mitterling, L. A. 1967. Thirsty birds will damage fruit. Milestones in Conn. Ag. and Home. Econ. 11(2):5-6.

115. Mott, D. F. , J. F. Besser, and D. J. Cunningham. 1974. An evaluation of an aerial applicaton of methiocarb for protecting ripening grain sorghum from blackbirds at Washita NWR, Oklahoma. Unpubl. rept. No. 46b, Work Unit DF-102.3, Denver Wildl. Res. Ctr. 11pp.

116. Mott, D. F., and L. E. Lewis. 1976. Methiocarb: A bird repellent on ripening grain sorghum. Sorghum Newsl. 19:95-97.

117. Mott, D. F., and C. P. Stone. 1973a. Bird damage to blueberries in the United States. U.S. Bur. Sport Fish. Wildl., Spec. Sci. Rept. Wildl. No. 172, 15pp.

118. Mott, D. F., and C. P. Stone. 1973b. Predation on corn earworms by red-winged blackbirds. Murrelet 54(1):8-10.

119. Mott, D. F., J. F. Besser, R. R. West, and J. W. DeGrazio. 1972. Bird damage to peanuts and methods for alleviating the problem. Proc. Vertebr. Pest Control Conf. Fresno, Calif. 5:118-120.

120. Mott, D. F., R. R. West, J. W. DeGrazio, and J. L. Guarino. 1972. Foods of the red-winged blackbird in Brown County, South Dakota. J. Wildl. Manage. 36(3):983-987.

121. Moulton, D. W. 1979. Evaluation of methiocarb for repelling blackbirds from cultivated wild rice. J. Wildl. Manage. 43:747-751.

122. Murray, M. L. 1972. An assessment of damage to Louisiana pecan orchards by the common crow (Corvus brachyrhyanchos). Unpubl. Master's Thesis, Lousiana State Univ. 46pp.

123. National Geographic Society. 1982. A field guide to the birds of North America. National Geographic Soc., Washington, D.C. 464pp.

124. Neff, J. A. 1936. Protecting crops from damage by horned larks in California. Bur. Biol. Survey, U. S. Dept. Ag. Wildl. Res. and Manage. Leaflet BS-64, Washington, D.C. 10pp.

125. Neff, J. A. 1937. Procedure and methods in controlling birds injurious to crops in California, Part II: Control Methods. Unpubl. handbook, U. S. Dept. Ag., Bur Biol. Survey and Calif. Dep. Ag., Sacramento, Calif. 153pp.

126. Neff, J. A. and B. Meanley. 1957. Blackbirds and the Arkansas rice crop. Arkansas Ag. Exp. Sta., Fayetteville, Ark., Bulletin 584, 89pp.

127. Office of Federal Register. 1978. Issuance of a specific exemption to use Mesurol® to control blackbirds on wild rice. Federal Register 43(178):40915.

128. Otis, D. L. and J. F. Besser. 1984. Estimation of bushel/acre loss of ripening field corn to blackbirds from proportion of ears damaged. Unpubl. Bird Damage Res. Rept. No. 316, Denver Wildl. Res. Ctr. 12pp.

129. Palmer, T. K. 1970a. Chemical and physical methods of controlling damage by waxwings. Unpubl. rept., Calif. Dept. Ag., Sacramento, Calif. 4pp.

130. Palmer, T. K. 1970b. The housefinch and starling in relation to California's agriculture. Proc. General Meeting of the Working Group on Granivorous Birds, IBP. PT Sec., The Hague, Holland, Sept. 6-8, 1970. pp275-290.

131. Pearson, E. W., and W. F. Shake. 1971. Use of Av-Alarm to control birds damaging cultivated blueberries in Michigan. Unpubl. rept., Denver Wildl. Res. Ctr. 14pp.

132. Pearson, E. W., P. R. Skon, and G. W. Corner. 1964. Studies of audio and ultrasonic frightening devices for controlling damage by birds. Unpubl. rept., Denver Wildl. Res. Ctr. 24pp.

133. Peterson, R. T. 1947. A field guide to the birds. Houghton Mifflin Company, Boston, Mass. 290pp.

134. Pfeifer, W. K. 1975. Blackbirds and sunflower. National Sunflower Grower 2(5):12.

135. Pierce, R. A. 1970. Bird depredation on rice and other grains in Arkansas. Proc. Bird Control Semin., Bowling Green, Ohio 5:101-109.

136. Pough, R. H. 1949. Audubon land bird guide. Doubleday and Co., Inc., Garden City, N.Y. 312pp.

137. Pough, R. H. 1950. Audubon water bird guide. Doubeday and Co., Inc., Garden City, NY. 352pp.

138. Pough, R. H. 1957. Audubon western bird guide. Doubleday and Co., Inc., Garden City, NY. 316pp.

139. Robbins C. S., B. Bruun, and S. Zim. 1966. A guide to field ~~of~~ identification of birds of North America. Golden Press, New York, NY. 340pp.

140. Rogers, J. G., Jr. and J. T. Linehan. 1977. Some aspects of grackle feeding behavior in newly planted corn. J. Wildl. Manage. 41(3):444-447.

141. Royall, W. C., Jr. 1969. Trapping house sparrows to protect experimental grain crops. U.S. Bur. Sport Fish. Wildl., Wildl. Leaflet 484. 4pp.

142. Royall, W.C., Jr., T. J. DeCino, and J. F. Besser. 1967. Reduction of a starling population at a turkey farm. Poult. Sci. 46(6):1494-1495.

143. Schafer, E. W. Jr., W. A. Bowles, Jr. and J. Hurlbut. 1983. The acute oral toxicity, repellency, and hazard potential of 998 chemicals to one or more species of wild and domestic birds. Arch. Environm. Contam. Toxicol. 12:355-382.

144. Schafer, E. W., Jr., R. B. Bruton, and N. F. Lockyer. 1976. Evaluation of 45 chemicals as chemosterilants in adult male quail (Coturnix coturnix). J. Reprod. Fert. 48:371-375.

145. Schmidt, R. H. and R. J. Johnson. Dispersal recordings, source of supply. University of Nebraska, Lincoln, NE. 23pp.

146. Searnans, T. W. and J. W. Calick. 1983. An assessment of bird damage and bird control measures in New York vineyards. Natural Resources Res. & Ext. Series Bull. No. 19, Ithaca, NY. 15pp and appendix.

147. Sedgwick, J. A., J. L. Oldemeyer, and E. L. Smith. 1983a. Shrinkage of sunflower related to head size, percent damage, and time of damage. Unpubl. Bird Damage Res. Rept. No. 282, Denver Wildl. Res. Ctr. 31pp.

148. Sedgwick, J. A., J. L. Oldemeyer, and E. L. Smith. 1983b. Growth compensation in sunflowers. Unpubl. Bird Damage Res. Rept. No. 283, Denver Wildl. Res. Ctr. 23pp.

149. Simpson, G. 1972. Some approaches to controlling depredations by crows and jays in Tulare County. Proc. Vertebr. Pest Control Conf., Fresno, CA 5:112-117.

150. Smith, E. L. and J. L. Oldemeyer. 1982a. Growth compensation in sunflower. Unpubl. Bird Damage Res. Rep. No. 216, Denver Wildl. Res. Ctr. 8pp.

151. Smith, E. L. and J. L. Oldemeyer. 1982b. Shrinkage of sunflower related to head size, percent damage and time of damage. Unpubl. Bird Damage Res. Rept. No. 217, Denver Wildl. Res. Ctr. 16pp.

152. Statistical Reporting Services. 1983a. Crop production: 1982 annual summary, U.S. Dept. Agric., Washington, D.C. 61pp.

153. Statistical Reporting Service, U.S. 1983b. Agricultural prices. Released January 31, 1983. 56pp.

154. Stewart, P. A. 1973. Starlings eat larvae on corn ears without eating corn. Auk 90(4):911-912.

155. Stickley, A. R., Jr., and J. L. Guarino. 1972. A repellent for protecting corn seed from blackbirds and crows. J. Wildl. Manage. 36(1):150-152.

156. Stickley, A. R., Jr., and C. R. Ingram. 1977. Methiocarb as a bird repellent for mature sweet corn. Proc. Bird Control Seminar, Bowling Green, Ohio 7:228-238.

157. Stickley, A. R., Jr., and C. R. Ingram. 1979. Testing candidate chemical blackbird repellents in agricultural crops and seeds in Ohio (Methiocarb on mature sweet corn, 1976). Unpubl. Bird Damage Res. Rept. No. 106, Denver Wildl. Res. Ctr. 18pp.

158. Stone, C. P. 1973a. Bird damage to tart cherries in Michigan, 1972. Proc. Bird Control Seminar, Bowling Green, Ohio 6:19-23.

159. Stone, C. P. 1973b. Bird damage to agriculutral crops in the U.S. -- a current summary. Proc. Bird Control Seminar, Bowling Green, Ohio 6:264-267.

160. Stone, C. P., and D. F. Mott. 1973. Bird damage to sprouting corn in the United States. U.S. Bur. Sport Fish. Wildl., Spec. Sci. Rept.--Wildl. No. 173. 28pp.

161. Stone, C. P., W. F. Shake, and D. J. Langowski. 1974. Reducing bird damage to highbush blueberries with a carbamate repellent. Wildl. Soc. Bull. 2(3):135-139.

162. Tobin, M. E. 1982. Relative economic importance of three bird species which cause damage to California wine grapes. Unpubl. Bird Damage Res. Rept. No. 244. Denver Wildl. Res. Ctr. 12pp.

163. Twedt, D. J. and J. F. Glahn. 1982. Reducing starling depredations at livestock feeding operations through changes in management practices. Proc. Vertebr. Pest Control Conf., Monterey, Calif. 10:159-163.

164. Webb, J. S., and W. C. Royall, Jr. 1970. National survey of blackbird-starling roosts. Proc. Bird Control Seminar, Bowling Green, Ohio 5:134-135.

165. West, R. R. 1968a. Protecting sprouting corn from pheasants with DRC-736. P12 in Proc. 13th Ann. Conf., Central Mountains and Plains Section, Wildl. Soc., Pingree Park, CO.

166. West, R. R. 1968b. Reduction of a winter starling population by baiting its preroosting areas. J. Wildl. Manage. 32(3):637-640.

167. West, R. R., and J. F. Besser. 1967. Dip-netting blackbirds in a marsh roost in Missouri. Inland Bird Banding News 39(4):91.

168. West, R. R., and J. F. Besser. 1977. Selection of toxic poultry pellets from cattle rations by starlings. Proc. Bird Control Seminar, Bowling Green, Ohio 7:242-244.

169. West, R. R., and J. H. Dunks. 1969. Repelling boat-tailed grackles from sprouting corn with a carbamate compound. Texas J. Sci. 21(2):231-233.

170. West, R. R., R. B. Brunton, and D. J. Cunningham. 1969. Repelling pheasants from sprouting corn with a carbamate insecticide. J. Wildl. Manage. 33(1):216-219.

171. Wilson, R. C. 1974. An assessment of crow control techniques in pecan orchards in Louisiana. Unpubl. Ms Thesis-Northwestern La. State Univ., Ruston, LA. 84pp.

172. Woronecki, P. P. and R. A. Dolbeer. 1983. Are starlings a potential threat to certain corn hybrids? Proc. Bird Control Seminar, Bowling Green, Ohio 9:109-113.

173. Woronecki, P. P., R. A. Dolbeer and R. A. Stehn. 1981. Response of blackbirds to Mesurol® and Sevin® applications on sweet corn. J. Wildl. Manage. 45(3):693-701.

174. Zabadal, T. J., and R. L. Hothem. 1979. Mesurol®--it's for the birds. Wines and Vines 60(11):38-41.

175. Zajanc. A., 1958. Waterfowl depredation and control methods. Unpubl. rept., Denver Wildl. Res. Ctr. 9pp

Appendix A. Estimated Annual Losses for Specif[illegible] U.S. Agricultural Crops. a/

| Crop | Species of Birds Causing Loss | Best Estimate of Local or National Loss (Survey year) |  |  | Loss @ 1973-82 Avg. Price ($ million) | References | Extrapolated U. S. Loss @ 1973-82 Avg. Price ($ million) | Source of Estimates |
|---|---|---|---|---|---|---|---|---|
|  |  | Cwt. (million) | $/Cwt | $ (million) |  |  |  |  |
| Blue-berries (culti-vated) | Starlings, robins, grackles, orioles, houses finches | 0.32 | 50.00 (1973) | 1.6 | 2.0b/ | Mott & Stone (1973) | 2.0b/ | Questionnaire survey in 14 States in 1973. |
| Cherries | Robins, starlings orioles, grosbeaks, catbirds, house finches, waxwings | 0.404 | 7.50 (1972) | 3.1 | 11.0 | Stone (1973b) | 10.9 | Objective survey in MI tart cherries in 1972. National loss in tart & sweet cherries est. at min. % age of MI tart cherry loss in 1972. |
| Corn, field, ripening | Blackbirds | 4.3 | 4.64 (1981) | 20.0 | 18.8 | Besser & Brady (1982) | 32.8 | From objective survey of 10 major corn producing States. |
| Corn, field, sprouting | Blackbirds, crows, pheasants | 0.67 | 3.88 (1971, 1978, 1979) | 2.6 | 2.9 | Stone & Mott (1973),<br>Heisterberg (1979, 1980) | 9.8 | Objective survey in VA, KY & TN. National loss per acre at 10% of 3-State loss. |
| Corn, sweet, ripening | Blackbirds | 0.074 | 6.77 (1973) | 0.5 (1966) | 0.7 | Anonymous (1967) | 5.3 | Questionnarie surevey in MD in 1966. National loss est. at 27% of MD per acre loss in 1966. |
| Grains, feed (live-stock) | Starlings, blackbirds, house sparrows | 0.12 | 6.00 (1979) | 0.7 | 0.7 | Glahn et al. (1980) | 7.3 | Objective survey of TN in 1979. National loss est. from wintering starlings and black-bird numbers in U. S. |
| Grains, small (wheat) | Mallards & other waterfowl | 0.93 | 6.47 (1981) | 0.6 | 0.5 | Knittle & Porter (in prep.) | 0.5 | U.S. Fish & Wildlife Service est. for ND, SD, & MN. |

Appendix A. (cont.)

| Crop | Species of Birds Causing Loss | Best Estimate of Local or National Loss (Survey year) | | | Loss @ 1973-82 Avg. Price ($ million) | References | Extrapolated U. S. Loss @ 1973-82 Avg. Price ($ million) | Source of Estimates |
|---|---|---|---|---|---|---|---|---|
| | | Cwt. (million) | $/Cwt. | $ (million) | | | | |
| Grapes | Starlings, house-finches, house sparrows robins, waxwings, bluebirds | 0.542 | 8.13 (1975) | 4.4 | 5.7 | DeHaven (1974a)<br>Crase et al. (1976) | 5.7 | Objective survey in CA wine grapes & questionaire survey in 13 States. |
| Peanuts, windrowed | Grackles, crows | 0.0072 | 10.27 (1971) | 0.07 | 0.15 | Mott et al. (1972) | 1.5 | Objective survey in 3 OK counties in 1969. National est. at 10X this loss. |
| Pecans | Crows, bluejays | 0.016 | 35.00 (1974) | 0.58 | 0.85 | Murray (1975) | 3.4 | Objective survey of 4 LA parishes. National loss est. at 4X LA loss in 1974. |
| Rice, ripening | Blackbirds | 0.39 | 3.89 (1968) | 1.5 | 3.8 | Pierce (1970) | 7.6 | Questionnaire survey in AR. National loss est. at 2X that of AR in 1968. |
| Rice, sprouting | Blackbirds | 0.09 | 3.89 (1968) | 0.4 | 0.9 | Pierce (1970) | 3.7 | Questionnaire survey in AR. National loss est. at 4X AR loss in 1968. |
| Rice, wild | Blackbirds | 0.0033 | 450.00 (1978) | 1.5 | 1.5 | Office Federal Register (1978) | 1.5 | Estimate by MN Dept. Ag. |
| Sorghum, grain, | Blackbirds & sparrows | 1.2 | 4.83 (1974) | 5.8 | 4.8 | Knittle & Guarino (1976) | 4.8 | Questionnaire survey in 23 States in 1974. |
| Sunflower, ripening | Blackbirds | 0.753 | 11.55 (1980) | 8.7 | 7.4 | DeHaven (1982) | 7.4 | Objective surveyin ND, SD & MN. |
| Vegetables sprouting lettuce & other vegetablesd/ | Horned larks blackbirds, starlings, & crowned sparrows | 0.09b/ | 6.93c/ (1982) | 0.6 | 0.8 | DeHaven (1974b) | 0.8 | Questionnaire survey of 21 CA counties. |
| Wheat, sprouting | Starlings | 0.13 | 3.75 (1977) | 0.5 | 0.9 | Dolbeer et al. (1978-79) | 0.9 | Objective survey in TN & KY in 1977. |

Appendix A. (cont'd)

Summary:

| | Type of Survey | | |
|---|---|---|---|
| | Objective | Subjective | Total |
| Ripening and Swathed Grains | 18.8 | 34.5 | 53.2 |
| Sprouting Grains | 3.8 | 10.6 | 14.4 |
| Oilseed | 7.6 | 1.4 | 9.0 |
| Fruits | 16.7 | 1.9 | 18.6 |
| Other Crops | 1.6 | 9.2 | 10.8 |
| Totals | 48.5 | 57.6 | 106.1 |

a/ Extrapolation of fragmentry data made to obtain an estimate of annual loss to birds for all U. S. agricultural crops.

b/ 1982 price.

c/ Lettuce equivalent.

d/ Includes sprouting sugar beets.

Appendix B. Daily Damage Capabilities of Individuals of Selected Species of Birds to Specific Maturation Stages of Some U.S. Agricultural Crops.

| Crop | Species | Ounces Damaged | Est. $ lossa/ |
|---|---|---|---|
| Corn, sprouting | Ring-necked Pheasant, male | 3.50 | 4.86b/ |
| Corn, sprouting | Common Grackle | 0.82 | 1.14b/ |
| Corn, milk and dough stages | Red-winged Blackbird, male | 1.40 | 0.004 |
| Corn, dented | Common Grackle | 0.50 | 0.0014 |
| Corn, mature | Mallard male | 2.08 | 0.024 |
| Corn, mature | Canada goose | 5.28 | 0.061 |
| Corn, sweet, milk stage for canning | Red-winged Blackbird, male | 1.40 | 0.016c/ |
| Grain sorghum, dough stage | Red-winged Blackbird, male | 0.50 | 0.0012 |
| Grain sorghum dough stage | House Sparrow | 0.36 | 0.0009 |
| Grapes, wine | Starling | 2.20 | 0.0157 |
| Grapes, wine | American Robin | 2.10 | 0.0150 |
| Grapes, wine | House Finch | 0.60 | 0.0042 |
| Rice, dough stage | Tri-colored Blackbird | 0.80 | 0.0049 |
| Rice, mature | Red-winged Blackbird | 0.44 | 0.0027 |
| Rice, mature | Common Grackle | 0.57 | 0.0035 |
| Rice, mature | Brown-headed Cowbird | 0.49 | 0.0030 |
| Rice, mature | Mallard, male | 2.52 | 0.015 |
| Rice, seeded | Fulvous Whistling Duck | 2.00 | 0.48b/ |
| Sunflower, green bowls | Red-winged Blackbird, male | 1.42 | 0.0078d/ |
| Sunflower, yellow bowls | Red-winged Blackbird, male | 0.89 | 0.0049d/ |
| Wheat, mature | Mallard, male | 2.56 | 0.011 |
| Wheat, mature | Blue-winged Teal | 0.96 | 0.004 |
| Wheat, mature | Canada Goose | 6.56 | 0.028 |

---

a/ At average price of commodity for 1973-82 period
b/ Projected figure based on yield of mature crop
c/ Doubled for trim
d/ 1983 price

Appendix C. A Table of 200 Random 2-Digit Numbers for Locating Random Sampling Points in Crop Fields.

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 1. | 07 | 60 | 09 | 21 | 47 | 06 | 97 | 49 | 21 | 71 |
| 2. | 63 | 28 | 07 | 63 | 20 | 22 | 31 | 76 | 81 | 84 |
| 3. | 18 | 47 | 93 | 37 | 51 | 78 | 95 | 46 | 37 | 38 |
| 4. | 35 | 73 | 85 | 78 | 80 | 16 | 36 | 29 | 73 | 31 |
| 5. | 58 | 11 | 32 | 98 | 16 | 16 | 66 | 13 | 33 | 65 |
| 6. | 97 | 57 | 62 | 00* | 69 | 55 | 44 | 89 | 16 | 13 |
| 7. | 09 | 99 | 62 | 23 | 50 | 78 | 67 | 04 | 29 | 21 |
| 8. | 83 | 97 | 05 | 67 | 53 | 74 | 85 | 86 | 14 | 84 |
| 9. | 73 | 40 | 79 | 62 | 49 | 20 | 13 | 59 | 51 | 46 |
| 10. | 88 | 57 | 10 | 80 | 64 | 47 | 49 | 97 | 75 | 75 |
| 11. | 31 | 03 | 30 | 42 | 12 | 15 | 63 | 00* | 88 | 80 |
| 12. | 00* | 62 | 69 | 03 | 77 | 91 | 15 | 74 | 41 | 47 |
| 13. | 69 | 32 | 27 | 86 | 25 | 41 | 06 | 63 | 96 | 11 |
| 14. | 26 | 28 | 64 | 26 | 70 | 22 | 92 | 47 | 72 | 27 |
| 15. | 38 | 18 | 85 | 66 | 39 | 38 | 29 | 97 | 09 | 98 |
| 16. | 70 | 17 | 52 | 78 | 26 | 81 | 01 | 66 | 14 | 52 |
| 17. | 49 | 27 | 79 | 67 | 81 | 05 | 66 | 11 | 18 | 97 |
| 18. | 05 | 87 | 28 | 83 | 28 | 48 | 12 | 47 | 16 | 19 |
| 19. | 76 | 89 | 30 | 04 | 31 | 53 | 14 | 76 | 64 | 85 |
| 20. | 16 | 99 | 56 | 06 | 29 | 75 | 24 | 59 | 29 | 91 |

* Convert to 100

## Appendix D. Federal Permit Requirements for Scaring or Killing Birds Damaging U.S. Agricultural Crops.

---

### Scaring

#### Not required

All species except endangered or threatened species (see Sect. 17.11, Title 50, Code of Federal Regulations).

### Killing

#### Not required

Pigeon, Domestic or feral (Rock Dove)
Sparrow, House
Starling, European
Other undesirable exotics

#### Not required when committing or about to commit depredations

Blackbird, Brewer's
Blackbird, Red-winged
Blackbird, Rusty
Blackbird, Tri-colored
Blackbird, Yellow-headed

Cowbird, Brown-headed
Cowbird, Bronzed

Crow, American
Crow, Fish
Crow, Northwestern

Grackle, Boat-tailed
Grackle, Common
Grackle, Great-tailed

Magpie, Black-billed
Magpie, Yellow-billed

NOTE: See Sections 21.44, 21.45, and 21.46, Title 50, Code of Federal Regulations for exceptions applicable to the Horned Lark, goldfinches, House Finch, meadowlarks, and woodpeckers in California; the Purple Gallinule in Louisiana; and the Scrub and Steller's Jay in Oregon and Washington.

### Required

Generally for all other species

## Appendix E. Common and Scientific Names of Birds Damaging Crops (mentioned in text).

| Common | Scientific |
|---|---|
| Blackbird, Brewer's | Euphagus cyanocephalus |
| Blackbird, Red-winged | Agelaius phoeniceus |
| Blackbird, Tricolored | Agelaius tricolor |
| Blackbird, Yellow-headed | Xanthocephalus xanthocephalus |
| Bluebird, Eastern | Sialia sialis |
| Bluebird, Western | Sialia mexicana |
| Bobolink | Dolichonyx oryzivorous |
| Cardinal, Northern | Cardinalis cardinalis |
| Catbird, gray | Dumetella carolinensis |
| Coot, American | Fulica americana |
| Cowbird, Bronzed | Molothrus aeneus |
| Cowbird, Brown-headed | Molothrus ater |
| Crane, Sandhill | Grus canadensis |
| Crow, American | Corvus brachyrhynchos |
| Crow, Fish | Corvus ossifragus |
| Crow, Northwestern | Corvus caurinus |
| Dickcissel | Spiza americana |
| Dove, Mourning | Zenaida macroura |
| Dove, Rock | Columba livia |
| Dove, White-winged | Zenaida asiatica |
| Finch, House | Carpodacus mexicanus |
| House, Purple | Carpodacus purpureus |
| Flicker, Northern | Colaptes auratus |
| Gallinule, Common | (See Moorhen, Common) |
| Gallinule, Purple | Porphyrula martinica |
| Goldfinch, American | Carduelis tristis |
| Goldfinch, Lesser | Carduelis psaltria |
| Goose, Canada | Branta canadensis |
| Grackle, Boat-tailed | Quiscalus major |
| Grackle, Common | Quiscalus quiscula |
| Grackle, Great-tailed | Quiscalus mexicanus |
| Grosbeak, Black-headed | Pheucticus melanocephalus |
| Grosbeak, Rose-breasted | Pheucticus ludovicianus |
| Gull, Franklin's | Larus pipixcans |
| Jay, Blue | Cyanocitta cristata |
| Jay, Scrub | Aphelocoma coerulescens |
| Jay, Steller's | Cyanocitta stelleri |
| Lark, Horned | Eremophila alpestris |
| Magpie, Black-billed | Pica pica |
| Magpie, Yellow-billed | Pica nuttalli |

Appendix E. (cont.)

| Common | Scientific |
|---|---|
| Mallard | Anas platyrhunchos |
| Meadowlark, Eastern | Sturnella magna |
| Meadowlark, Western | Strunella neglecta |
| Mockingbird, Northern | Mimus polyglottos |
| Moorhen, Common | Gallinula chloropus |
| Oriole, Northern | Icterus galbula |
| Pheasant, Ring-necked | Phasianus colchicus |
| Pigeon, Band-tailed | Columba fasciata |
| Pigeon, Domestic or feral | Columba livia |
| Pipit, Water | Anthus spinoletta |
| *Pochard, Rosy-billed | Netta peposaca |
| Quail, California | Callipepla californica |
| Robin, American | Turdus migratorius |
| Sparrow, Golden-crowned | Zonotricha atricapilla |
| Sparrow, House | Passer domesticus |
| Sparrow, White-crowned | Zonotricha leucophrys |
| Starling, European | Sturnus vulgaris |
| Tanager, Scarlet | Piranga olivacea |
| Tanager, Western | Piranga ludoviciana |
| Teal, Blue-winged | Anas discors |
| *Teal, Speckled | Anas flavirostris |
| Thrasher, Brown | Toxostoma rufum |
| Towhee, Rufous-sided | Pipilo erythophthalmus |
| Waxwing, Cedar | Bombycilla cedrorum |
| Whistling-Duck, Black-bellied | Dendrocygna autumnalis |
| Whistling-Duck, Fulvous | Dendrocygna bicolor |
| *Whistling-Duck, White-faced | Dendrocygna vidauta |
| Woodpecker, Acorn | Melanerdes formicivorus |
| Woodpecker, Lewis | Melanerpes lewis |
| Woodpecker, Red-headed | Melanerpes erythrocephalus |

*South American species

## Appendix F. Methods Available to Protect U.S. Agricultural Crops from Bird Damage.

---

### Methods

#### Ecological

- Destruction of key habitat
  - Nesting
  - Loafing (including watering)
  - Roosting
- Supplemental feeding to reduce attractiveness of field
- Management to increase specific predators

#### Cultural

- Site selection
- Crop selection
- Variety selection for bird resistant characteristics
  - Long husks or glumes
  - Pendant ears
  - Low plant height
  - Thick or plastic seed coats
  - Smaller or larger seeds than preferred by species causing damage.
  - Thick rinds (fruits)
  - Preference by birds
- Planting synchrony
- Alteration of planting (and ripening) dates to avoid bird migration
  - Early dates
  - Late dates
- Seeding depth
- Wide-row planting
- Provision of alternate bird foods
  - Crop diversification
  - Buffer plantings
  - Delayed tillage
- Ripening synchrony
- Early harvest
- Use of driers

#### Mechanical

- Exploders, acetylene, propane, carbide
  - Sirens and whistles

Appendix F. (cont.)

---

Pyrotechnics
- Shell-crackers
- Bird bombs
- Bird whistles
- Whistle bombs
- Racket bombs
- Rope fire-crackers

Shooting
- .22 Rifle
- Large caliber rifle
- Shotgun

Patrol
- Walking
- Mobile
- Aerial

Amplified calls
- Alarm
- Distress
- Escape

Electronic Noise Production
- AV-Alarm
- Ultrasonics

Traps
- Decoy
- Nest-box

Protective Netting

Predator Models
- Stationary scarecrows
- Moving scarecrows

Revolving lights

Chemical

Repellents
- Seed treatments
- Crop sprays
- Genetic implantation in bird-resistant varieties

Frightening agents
- Feeding site baitings

Appendix F. (cont.)

---

Toxicants
    Feeding site baitings

Reproductive Suppressants
    Feeding site baitings

Insecticides
    To reduce crop attractiveness to birds

Herbicides and Dessicants
    To reduce crop attractiveness to birds
    To reduce period of crop vulnerability

# Appendix G. Sources of Supply of Non-chemical Materials Useful for Protecting U.S. Agricultural Crops from Bird Damage.

---

## Acetylene and Propane Exploders

Agricaid Limited, Elm Tree House, North Fambridge, Chemsford, Essex CM3 6NB, England (0621-74112)

Alexander-Tagg Industries, 395 Jacksonville Rd., Warminster, PA 18974 (215/675-7200)

Hub States Corp., 1000 N. Illinois St., Indianapolis, IN 46202

B.M. Lawrence and Co., 24 California St., San Francisco, CA 94111 (415/981-3650)

Pisces Industries, P.O. Box 6407, Modesto, CA 95355 (209/578-5502)

Reed-Joseph International Co., P.O. Box 894, Greenville, MS 38701 (601/335-5822)

Smith-Roles, Minot, ND 58701 (701/852-3726)

Wildlife Control, Margo Supplied Ltd. Site 8, Box 2, RR #6, Calgary, Alberta, Canada (403/285/9731)

## Pyrotechnics

Clow Seed Co., 1081 Harking Rd., Salinas, CA 93901 (408/422-9693P) whistlers, bird bombs)

J.E. Fricke Co., 40 N. Front St., Philadelphia, PA 19106 (fuse rope)

Marshall Hyde, Inc., P. O. Box 497, Port Huron, MI 48060 (313/982-2140) (shell-crackers, whistle bombs, racket bombs)

Munitions Filling Factory, St. Marys, New South Wales, Australia (shell-crackers)

O.C. Ag. Supply, Inc., 1328 S. Allec St., Anaheim, CA 92805 (714/991-0960) (shell-crackers)

Stone Co., Inc., Box 187, Dacono, CO 80514 (303/893-2580) (shell-crackers)

Western Fireworks Co., 2542 SE 13th Ave., Canby, OR 97013 (503/266-7770) (shell-crackers, rope firecrackers)

## Recorded Bird Calls

Signal Broadcasting Co., 2314 Broadway St., Denver, CO 80205 (303/571-5649) (Sells copies of Denver Wildlife Research Center calls).

Smith's Game Calls, P.O. Box 236, Summerville, PA 15864 (starling dist call)

Wildlife Technology, P.O. Box 1061, Hollister, CA 95023 (rents recordings of distress and alarm calls)

## Recorded Bird Calls (cont.)

Several universities and other non-commercial sources have recordings of 175 bird calls which may be made available under some circumstances. An annotated listing of these has been prepared by the Department of Forestry, Fisheries and Wildlife, 202 Natural Resources Hall, University of Nebraska, Lincoln, Nebraska 68583. (Schmidt and Johnson 1982).

## Recorded Bird Call and Sacrecrow

Saturn Inc., P. O. Box 21, Kathryn, ND 58049 (701/924-8645) (Distress call of a red-winged blackbird and a "pop-up" owl model).

## Electronic Noise Protection

Av-Alarm Crop., 657-D Conger St., Eugene, OR 97402 (503/342-1271) (electronic acoustical jamming device-Av-Alarm)

Bird-X, 325 Huron St., Chicago, IL 60610 (312/642-6871) (Av-Alarm)

## Kites, Balloons, and Scarecrows

Atmospheric Instrumentation Research, Inc., 1880 S. Flatiron Ct., Suite A, Boulder, CO 80301 (303/443-7187) (polyurethane tetrahedron balloons)

Bird-X, 325 W. Huron St., Chicago, IL 60610 (312/642-6871) (suspended model hawk)

W. Atlee Burpee Seed Co., 6350 Rutland Ave., Riverside, CA 92592 (714/689-1191) (inflatable plastic human figure)

Clow Seed Co., 1081 Harkins Rd., Salinas, CA 93901 (408/422-9693) (hawk-shaped kite)

Cochrane's of Oxford, Ltd., Leafield, Oxford, OX8 5NT, England (099387-641) (kite)

Coleman Equipment, Inc., 332 Madison Ave., New York, NY 10017 (212/687-2154) (moving, noise-making scarecrow)

R.M. Fay, Rt. 2 Box 2569, Grandview, WA 95930 (509/882-3258) (balloon-supported raptor kite)

High-as-a-Kite, 200 Gate Five Rd., Sausalito, CA 94965 (415/332-6355) (various kites)

Huge Co., Inc., P.O. Box 24198, St. Louis, MO 63130 (314/725-2555) (model owl)

Lentell Marketing, Elm Tree House, North Cambridge, Chemsford, Essex, CM3 6NB, England (0621-741112) (human figure)

Raven Industries, Inc., P.O. Box 1007, Sioux Falls, SD 57117 (605/336-2750) (Mylar tetrahedron balloons and blimps)

Appendix G. (cont.)

---

Teiso Kasei Co., Ltd., 350 S. Figueroa St., Suite 350, Los Angeles, CA 90071 (231/680-4349) (hawk model)

Tiderider, Inc., P.O. Box 9, Baldwin, NY 11510 (516/223-3838) (various kites)

Weather Measure Corp., P.O. Box 41257, Sacramento, CA 95841 (916/481-7565) (weather balloons)

## Netting and Trap Suppliers

Animal Repellents Inc. (ARI), P.O. Box 999, Griffin, GA 30224 (800/241-5064) (Durex$^R$ olefin mesh)

Internet, Inc., 2730 Nevada Ave. N., New Hope, MN 55427 (612/541-9690) (Conwed$^R$ netting)

J.A. Cissel Co., Inc., P.O. Box 339, Farmingdale, NJ 07727 (201/938-6600) (Toprite$^R$ netting)

Nichols Net and Twine Co., R. R. 3, Bend Road, East St. Louis, IL 66201 (618/876-7700) (Nylon netting)

Nylon Net Co., P.O. Box 592, Memphis, TN 38101 (901/525-8616) (Nylon netting)

Sterling Marine Products, 18 Label St., Montclair, NJ 07040 (201/783-9800) (Nylon netting)

## Vexar Trap Material Supplier

Valentine Equipement Co., 9706 S. Industrial Drive, Bridgeview, IL 60455 (312/599-1101) (Welded wire, hardware cloth, hexagonal netting, fencing, cage clips)

Appendix H. Chemical Products Registered for Protecting U.S. Agricultural Crops from Bird Damage (Manufacturer addresses footnoted).

| Bird | Problem | Chemical Agent | Product | Federal Registration No. | Mfgr. |
|---|---|---|---|---|---|
| Birds | Conifer seed | Repellent treatment | Gustafson 42-S Fungicide and Repellent | 7501-14 | 3 |
| Blackbirds (Red-winged blackbirds, yellow-headed blackbirds grackles, cowbirds) | Blueberries | Repellent spray | Mesurol 75WP | 3125-288AAa/ | 4 |
| | Cherries | Repellent spray | Mesurol 75WP | 3125-288AAa/ | 4 |
| | Corn, seed | Repellent treatment | Borderland Black Repellent | 7832-4 | 2 |
| | Corn, seed | Repellent treatment | Mesurol 50 Hopper Box Treater | 3125-309 | 3 |
| | Corn, ripening | Frightening Agent | Avitrol FC Corn Chops-99 | 11649-12 | 1<br>1 |
| | Livestock feed | Frightening Agent | Avitrol Corn Chops | 11649-6 | 1 |
| | Livestock feed | Frightening agent | Avitrol Double Strength Corn Chops | 11649-5 | 1 |
| | Livestock feed | Frightening agent | Avitrol Mixed Grains | 11649-4 | 1 |
| | Livestock feed | Frightening agent | Avitrol Sorghum | 11649-3 | 1 |
| | Livestock feed | Frightening agent | Avitrol Wheat | 11649-1 | 1 |
| | Sunflower, ripening | Frightening agent | Avitrol FC Corn Chops-99S | 11649-15 | 1 |
| Crows | Corn, seed | Repellent treatment | Crow Chex | 7832-2 | 2 |
| | Feeding sites | Frightening agent | Avitrol Double Strength, Whole Corn | 11649-8 | 1 |
| Finch, house | Cherries | Repellent spray | Mesurol 75WP | 3125-288a/ | 4 |
| Gulls | Feeding sites and airports | Frightening agent | Avitrol concentrate (25% 4-Aminopyridine in powdered sugar) | 11649-10 | 1 |
| Jay, blue | Blueberries | Repellent spray | Mesurol 75WP | 3125-288AAa/ | 4 |
| | Cherries | Repellent spray | Mesurol 75WP | 3125-288a/ | 4 |
| Oriole, northern | Blueberries | Repellent spray | Mesurol 75WP | 3125-288AAa/ | 4 |
| Pheasant, ring-necked | Corn, seed | Repellent treatment | Mesurol 50 Hopper Box Treater | 3125- | 3 |
| Pigeon, feral (Rock Dove) | Livestock feed | Frightening agent | Avitrol Whole Corn | 11649-7 | 1 |

Appendix H. (cont.)

| Bird | Problem | Chemical Agent | Product | Federal Registration No. | Mfgr. |
|---|---|---|---|---|---|
| Robin, American | Blueberries | Repellent spray | Mesurol 75 WP | 3125-288AA[a] | 4 |
|  | Cherries | Repellent spray | Mesurol 75 WP | 3125-288[a] | 4 |
| Sparrow, house | Cherries | Repellent spray | Mesurol 75 WP | 3125-288[a] | 4 |
|  | Livestock feed | Frightening agents | Avitrol Corn Chops | 11649-6 | 1 |
|  | Livestock feed | Frightening agents | Avitrol Sorghum | 11649-3 | 1 |
|  | Livestock feed | Frightening agents | Avitrol Wheat | 11649-1 | 1 |
| Starling, European | Blueberries | Repellent spray | Mesurol 75 WP | 3125-288[a] | 4 |
|  | Cherries | Repellent spray | Mesurol 75 WP | 3125-288[a] | 4 |
|  | Livestock feed | Frightening agent | Avitrol Powder Mix | 11649-11 | 1 |
|  | Livestock feed | Frightening agent | Avitrol Pelletized Feed | 11649-2 | 1 |
|  | Livestock feed | Frightening agent | Avitrol Double Strength Corn Chops | 11649-5 | 1 |
|  | Livestock feed | Toxicant | Starlicide Complete | 602-136 | 5 |
|  | Livestock feed | Toxicant | Starlicide Technical | 602-134 | 5 |
| Waxwing, cedar | Blueberries | Repellent spray | Mesurol 75 WP | 3125-288AA[a] | 4 |
|  | Cherries | Repellent spray | Mesurol 75 WP | 3125-288[a] | 4 |

Sources of Supply:

1. Avitrol Corp., P. O. Box 45141, Tulsa, OK 74145 (918/622-7763)
2. Borderland Products, Inc., P.O. Box 366, Buffalo, NY 14240 (716/825-3300)
3. Gustafson, Inc., 17400 Dallas North Parkway, Dallas, TX 75252 (214/931-8899)
4. Mobay Chemical Corp., P.O. Box 4913, Kansas City, MO 64120 (816/242-2000)
5. Ralston Purina Co., Checkerboard Square, St. Louis, MO 63188 (314/982-0111)

[a] See page 90 for a recent development in the registration status of Mesurol 75 WP for protecting fruit from birds.

## Appendix I. Preferred Method of Control for Serious Problems in Specific Crops.

| Crops-Birds | Preferred Method(s) |
|---|---|
| Ripening Grains (Row) | |
| Corn - Blackbirds | Chemical frightening agent<br>Mobile patrol w .22 rifle and shell-crackers |
| Ripening Grains (Non-row) | |
| Rice - Blackbirds | Mobile patrol w .22 rifle and shell-crackers |
| Swathed Grains | |
| Wheat - Waterfowl | Propane exploders, shell-crackers, and "lure" crop |
| Barley - Waterfowl | Propane exploders, shell-crackers, and "lure" crop |
| Oats - Blackbirds | Mobile patrol w .22 rifle |
| Sprouting Grains | |
| Corn - Blackbirds | Repellent seed treatment |
| Corn - Crows | Repellent seed treatment |
| Corn - Pheasants | Repellent seed treatment |
| Rice - Blackbirds | Repellent seed treatment |
| Rice - Ducks | Repellent seed treatment |
| Wheat - Starlings | Mobile patrol w .22 rifle or propane exploder |
| Ripening Oilseeds | |
| Sunflower - Blackbirds | Chemical frightening agent |
| Windrowed peanuts - Blackbirds | Propane exploders |
| Windrowed peanuts - Crows | Propane exploders |
| Ripening Fruits | |
| Grapes - Many species | Repellent sprays |
| Cherries - Many species | Repellent sprays |
| Blueberries - Many species | Netting - Repellent sprays |
| Other Agricultural Crops | |
| Pecans - Crows | Chemical frightening agent |
| Pecans - Blue jays | Nothing effective |
| Sweet corn - Blackbirds | Chemical frightening agent, patrol |
| Sprouting lettuce and sugar beets-Horned larks and crowned sparrows | Nothing effective [a] |
| Sprouting lettuce and sugar beets-Blackbirds and starlings | Patrol w .22 rifle and propane exploder |
| Livestock Feeds | |
| Pellet supplements - Starlings | Toxic baits |
| Grains - Starlings | Toxic baits |
| Grains - Blackbirds | Chemical frightening agents |
| Grains - Mourning dove | Propane exploder |

---

[a] Use of toxicants permitted in California only

## Appendix J. Common and Scientific Names[a] of U.S. Agricultural Crops Mentioned in Text.

| Common | Scientific |
|---|---|
| Almond, English or Persian | Prunus communis |
| Apple | Pyrus malus |
| Apricot | Prunus armeniaca |
| Avocado | Persea americana |
| Barley | Hordeum vulgare |
| Beet, red | Beta vulgaris |
| Beet, sugar | Beta vulgaris |
| Blueberry, highbush | Vaccinum corymbosum |
| Blueberry, lowbush | Vaccunum pennsylvanicum |
| Broccoli | Brassica oleracea var. botrytis |
| Brussels sprouts | Brassica oleracea var. gemmifera |
| Cabbage | Brassica oleracea var. capitata |
| Cauliflower | Brassica oleracea var. gemmifera |
| Carrot | Daucus carota |
| Cherry, sweet | Prunus avium var. sativa |
| Cherry, tart | Prunus cerasus |
| Corn, field | Zea mays |
| Corn, sweet | Zea mays var rugosa |
| Cucumber | Cucumis sativus |
| Date | Phoenix dactylifera |
| Fig | Ficus carica |
| Filbert | Corylus avellana |
| Grape, raisin | Vitis spp. |
| Grape, table | Vitis spp. |
| Grape, wine | Vitis vinifera |
| Grapefruit | Citrus maxima |
| Hazelnut | Corylus americana |
| Lemon | Citrus limonia |
| Lettuce | Lactuca sativa |
| Melon (watermelon and cantaloupe) | Cucumis melo |
| Nectarine | Prunus persica |
| Oats | Avena sativa |
| Olive | Olea europaea |
| Onion | Allium cepa |
| Orange | Citrus sinensis |
| Pea, garden | Pisum sativum |
| Pea, sugar | Pisum sativum |
| Peanut | Arachis hypogaea |
| Peach | Prunus persica |
| Pear | Pyrus communis |
| Pecan | Carya illinoensis |
| Persimmon | Diospyros virginiana |
| Pepper, Chili | Capsicum frutescens var. longum |
| Plum (Prune) | Prunus domestica |
| Pistachio | Pistacio vera |
| Potato | Solanum tuberosum |
| Radish | Raphanus sativum |
| Rape | Brassica napus |

Appendix J. (cont.)

| Common | Scientific |
|---|---|
| Rice, domestic | Oryza sativa |
| Rice, wild | Zizania aquatica |
| Sorghum, grain | Sorghum bicolor |
| Soybean | Glycine max |
| Spinach | Spinacia oleracea |
| Squash | Cucurbita pepo var. condensa |
| Strawberry | Fragaria spp. |
| Sunflower | Helianthus annuus |
| Tangerine | Citrus reticulata |
| Tomato | Lycopersicon esculentum |
| Turnip | Brassica rapa |
| Walnut, English or Persian | Juglans regia |
| Wheat, durum | Triticum aestivum |
| Wheat, red | Triticum aestivum |

---

a/ From Bailey (1925)

---

## Appendix K. Conversions of Proportion of Crop Damaged by Birds to Estimation of Losses in Corn, Sunflower, and Grapes.

---

| Corn [a] | | Sunflower [b] | | Wine Grapes [c] | |
|---|---|---|---|---|---|
| % Damage Frequency | bu/A Loss | % Damage Frequency | % Loss | % Damage Frequency | % Loss |
| 1-38 | 1 | 1-13 | 1 | 1-9 | 1 |
| 39-54 | 1 | 14-22 | 1 | 10-23 | 1 |
| 55-61 | 2 | 23-32 | 2 | 24-32 | 2 |
| 62-66 | 3 | 33-40 | 3 | 33-38 | 3 |
| 67-70 | 4 | 41-45 | 4 | 39-43 | 4 |
| 71-74 | 5 | 46-49 | 5 | 44-48 | 5 |
| 75-77 | 6 | 50-63 | 6-10 | 49-52 | 6 |
| 78-80 | 7 | 64-76 | 11-20 | 53-55 | 7 |
| 81-82 | 8 | 77-90 | 21-40 | 56-58 | 8 |
| 83-84 | 9 | 91-99 | 41-60 | 59-60 | 9 |
| 85-86 | 10 | | | 61-63 | 10 |
| 87-88 | 11 | | | 64-65 | 11 |
| 89 | 12 | | | 66-67 | 12 |
| 90 | 13 | | | 68-69 | 13 |
| 91 | 14 | | | 70-71 | 14 |
| 92 | 15 | | | 72 | 15 |
| 93 | 16 | | | 73-74 | 16 |
| 94 | 17 | | | 75 | 17 |
| 95 | 18 | | | 76-77 | 18 |
| 96 | 19 | | | 78 | 19 |
| 97 | 20 | | | 79 | 20 |
| 98 | 21 | | | 80 | 21 |
| 99 | 22 | | | 81 | 22 |
| 100 | 24 | | | 82-83 | 23 |
| | | | | 84 | 24 |
| | | | | 85 | 25 |
| | | | | 86 | 26 |
| | | | | 87 | 28 |
| | | | | 88 | 29 |
| | | | | 89 | 30 |
| | | | | 90 | 31 |
| | | | | 91 | 32 |
| | | | | 92 | 34 |
| | | | | 93 | 35 |
| | | | | 94 [d] | 36 |
| | | | | 95 | 38 |
| | | | | 96 | 40 |
| | | | | 97 | 41 |
| | | | | 98 | 43 |
| | | | | 99 | 44 |
| | | | | 100 | 46 |

---

[a] From South Dakota data. (Otis and Besser 1984)

[b] From North Dakota data. (Besser et al 1977)

[c] From California data. (Anonymous, undated)

[d] Largest percentage found in fields. Use caution for higher damage frequencies.

Note: More accurate estimates can be made by converting % damage frequency to loss for each plot sampled, then obtaining the average loss for all plots.

# GLOSSARY

Alarm call - The vocalization given by birds to warn of danger when a predator (such as man) is in the vicinity.

Bird bombs - A small firecracker with a range of about 50 yards, launched by a special pocket-sized pistol using a blank cap for ignition.

Broadcasted calls - Amplification of a recorded call of birds (such as distress, alarm, and escape) to frighten flocks from crop fields.

Certified applicator - One trained in the safe use and handling of those chemicals deemed by the U. S. Environmental Protection Agency to be too hazardous for the general public to use. Certification for hazardous bird damage control chemicals is obtained by attending training sessions and/or taking a written test.

Chemical frightening agent - A chemical applied to baits that causes the individual consuming the bait to exhibit abnormal behavior (emit distress cries, erratic flight, etc.) causing unaffected members of a flock of birds to change feeding, loafing, and roosting locations.

Chemosterilants - A chemical agent that permanently prevents production of young birds by a breeding adult.

Control - The management of bird-crop conflicts to reduce damage.

Decoy traps - A large trap (often 20x40x6ft) with an entrance suspended from the top, where the main attractant is feeding birds of the same species.

Distress call - The vocalization given by birds when seized by a predator (such as man).

Enumerator - One who makes and records prescribed field measurements.

Exploder - A small gas-powered cannon producing a noise about 9 times as loud as a 12 gauge shotgun blast.

Flasher - An object that moves or rotates in the wind.

Frightening devices - Exploders, flashing lights, balloons, models, streamers, distress calls, alarm calls, and noise that moves birds from a crop field being damaged.

Habitat manipulation - The altering of an areas vegetative characteristics to discourage use by a particular species of bird.

Lure crop - A bird damaged crop where birds are allowed to continue to feed without disturbance. The crop is usually purchased or grown by the government.

MAC trap = Modified Australian Crow Trap - A medium-sized trap (often 6x8x6ft) with an entrance suspended from the center of the top of the trap, where the main attractant is a few feeding birds of the same species. Birds fly to the highest points in the trap when attempting to escape. Birds usually are unable to relocate the entrance.

Non-target species - An animal at which a control measure is not directed.

Objective survey - A survey wherein bird damage is measured on randomly chosen plots and fields within the sample area.

Pyrotechnics - Materials, such as fireworks, used as flares or signals.

Random Sampling Point - A point chosen to fall any place within a field, usually determined by selecting a random row and a random number of paces from a selected corner of a field.

Random selected fields - Fields that are randonly chosen from a pool of all fields planted to a particular crop in the area to be sampled.

Registered chemical - A chemical approved by approprite governmental agencies for use in a specific formulation for a specified purpose.

Repellent, chemical - A chemical substance which discourages use of a food by a specific bird.

Rotating exploder - A small cannon mounted in a circular plane atop a tripod so that each firing causes the exploder to move in a new direction for the succeeding explosion.

Sample plot - A given area randomly chosen within a field.

Scarecrow - An object, typically suggesting a human figure, set up to frighten birds away from crops.

Shell-cracker - A 12-gauge shotgun shell containing a powerful firecracker (instead of shot) designed to explode about 100 yards from the gunner.

Subjective survey - A survey of growers or crop specialist opinions on the amount of bird damage occurring in a given crop.

Target Species - A species of bird at which a control measure is directed.

## Registration Status of Mesurol® 75% Wettable Powder

In April 1985, a review of the toxicology of Mesurol® resulted in a reduction of the no-effect level to 5 ppm residue in certain agricultural crops. Therefore the manufacturer found it necessary to delete cherries and blueberries, from the Mesurol® 75% Wettable Powder label. The manufacturer is presently reviewing its data to determine the feasibility of reducing crop residues to a <5 ppm level by changing the use pattern, i.e. lower application rates and/or longer pre-harvest treatment periods. If feasible the label will be re-established.